Technical highlights

Invasive plant and animal research
2017–18

Queensland Government

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Cover photo: *Aceria lantanae* on lantana at Charters Towers

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Introduction

This document summarises the 2017–18 research program of the Invasive Plants and Animals Research group in Biosecurity Queensland. Our applied research program aims to better manage Queensland's worst weeds and pest animals, reducing their impacts on agriculture, the environment and the community.

Our work is undertaken at five centres across the state:

- Ecosciences Precinct, Dutton Park
- Health and Food Sciences Precinct, Coopers Plains
- Pest Animal Research Centre, Toowoomba
- Tropical Weeds Research Centre, Charters Towers
- Tropical Weeds Research Centre, South Johnstone.

We also collaborate with numerous Queensland, interstate and overseas organisations. Higher degree students are supported to work on several research projects in weed and pest animal management.

The research projects summarised in this document cover the development of effective control strategies and methods (e.g. biocontrol and herbicides), as well as improved knowledge of pest species' biology and assessment of pest impact.

Notable achievements of the research program for 2017–18 are outlined below.

Invasive plant research

- We continue to assess new biological agents for control of prickly acacia, Navua sedge, bellyache bush, mikania, lantana, giant rat's tail grass, mother-of-millions, cat's claw creeper and several cacti (*Cylindropuntia* spp.). Also, we are undertaking mass rearing and release of biocontrol agents that have been approved for release in Australia to target parkinsonia, lantana, parthenium and *Cylindropuntia* cacti. We submitted to the Australian Government regulators an application for release of the first of hopefully a number of agents for bellyache bush. After a long delay, the application to release a gall fly against Siam weed is in its final stages.
- Projects are supporting state and national eradication programs for numerous weeds, including red witchweed, miconia, mikania and limnocharis. Researchers have developed a suite of treatment methods to deplete the seed bank of red witchweed within a relatively short time frame. Importantly, efficacy can be monitored by burying sachets of seeds, then recovering them and assessing them for number and viability.
- Trials are identifying effective herbicides, application rates and techniques (e.g. splatter gun, weed sniper and spray misting) for control of a number of weeds in Queensland, including prickly acacia, chinee apple, night-blooming cereus, stevia, rubber vine, cabomba, sagittaria, bogmoss, glush weed, giant rat's tail grass and gamba grass. Three projects are investigating difficulties in the conventional control of giant rat's tail grass and potential improvements.
- We are studying the ecology of a number of weeds to assist management. Information gained such as seed longevity and age at maturity indicate the timing and duration of treatment needed at a site.

Pest animal research

- Deer have been recognised as a growing pest problem nationally. The new Centre for Invasive Species Solutions (CISS) is therefore supporting two projects on cost-effective management of deer. These are national projects drawing on a wide range of expertise and situations to develop management guidelines.
- The impact of a new strain of rabbit haemorrhagic disease virus released in March 2017 has been mixed; however, it has raised awareness of the need to supplement biocontrol with conventional control such as warren ripping. This has resulted in substantial declines in rabbit numbers being recorded and maintained in the Granite Belt.
- We assessed a new 1080 feral cat bait (Eradicat®) on a broad scale in central Queensland. A combination of a network of remote cameras and mortality collars on cats indicated a 29–40% reduction in cat population size. Monitoring of non-target species at risk such as corvids recorded no impacts. The benefits of reduced cat abundance to threatened prey populations are being determined in a collaborative doctorate study. Further trials are planned, to gain approval for routine use of the bait in Queensland.
- Initial assessment of the use of fruit and vegetable baits to control feral pigs indicates minimal non-target impact and high efficacy. Similar data is being analysed for aerial application of meat baits. The data is necessary for the Australian Pesticides and Veterinary Medicines Authority (APVMA) to support the continuation of these baiting practices in Queensland.
- We continue to monitor the abundance of kangaroos, wild dogs and other wildlife, and pasture biomass and condition before and after the erection of two large cluster fences in south-western Queensland. Data is being collected on individual properties both inside and outside the clusters. With funding from CISS, the project will now be able to examine the production and economic benefits from cluster fencing. Similar work will be undertaken in Western Australia, providing a valuable comparison. This evaluation will help direct future investment in cluster fences and fine-tune current operations.

Research services

- At Coopers Plains, our chemistry group produces 1080 solution for use in pig, dog and fox baits. The group also tests various poisons as possible causes of death for animal mortalities reported by the public. In addition, testing for residues in baits is carried out to quantify how long chemicals last in the environment.
- We obtain minor-use permits from the APVMA as required for certain weed species, herbicides, application methods and situations or environments.

Funding, collaboration and research priorities

In the 2017–18 financial year, Biosecurity Queensland's Invasive Plants and Animals Research program received funding from a number of sources. Queensland Government base funds provided $2.4 million; contributions from the Land Protection Fund amounted to $2.4 million; and funding under contracts with external partners totalled $0.9 million (see 'External funding', page 30). Notable funding bodies for the latter were the Australian Government, AgriFutures, Meat and Livestock Australia and CISS.

Our research program for 2017–18 was endorsed by the Research Review Committee—a group of senior scientific, operations and policy staff from Biosecurity Queensland plus representatives from our external stakeholders, including local government, AgForce, the Queensland Farmers' Federation and NRM Regions Queensland. The committee critically reviews proposed project outcomes and allocated investments, and makes recommendations on strategic priorities, existing research gaps and projects due for scientific review.

Further information

For further information, visit the 'Invasive plant and animal research' page at daf.qld.gov.au. To obtain journal articles and scientific reports, email the project leaders (see 'Research staff', page 31). In addition, you can browse our recent scientific publications in the eResearch archive at biosecurity.qld.gov.au (search 'eResearch archive').

Part 1: Invasive plant research

1. Weed seed dynamics

Project dates

August 2007 – June 2020

Project team

Shane Campbell, Simon Brooks and Dannielle Brazier

Project summary

There are many weeds for which we know very little about seed ecology and longevity. This information is needed when developing control programs to indicate how long infested sites need treatment, providing there is no further input from neighbouring areas or mature plants. In this project, we are investigating the seed longevity of priority weeds by burying seeds enclosed in bags in two different soil types (black clay and river loam), with and without grass cover and at four burial depths (0 cm, 2.5 cm, 10 cm and 20 cm). The weeds investigated include yellow oleander, mesquite, prickly acacia, chinee apple, parthenium, lantana, gamba grass, calotrope, leucaena, yellow bells, neem, stevia and sicklepod.

We are also undertaking a seedling emergence trial to quantify the environmental conditions influencing the field emergence of neem, leucaena, prickly acacia, chinee apple and mesquite seeds. We have recorded seedling emergence after several rainfall events. Neem tree seedling emergence is consistent with short-term persistence, while prickly acacia and leucaena are displaying typical emergence patterns for weeds with long-lived seed banks. These trends are consistent with data from the buried seed packet longevity trial.

We will compare the results from the buried seed packet trials with those from a much more rapid laboratory test of relative longevity.

Collaborators

- Bob J Mayer, Senior Biometrician, Department of Agriculture and Fisheries
- Faiz Bebawi

Key publications

Bebawi, FF, Campbell, SD & Mayer, RJ 2013, 'Persistence of bellyache bush (*Jatropha gossypiifolia* L.) soil seed banks', *The Rangeland Journal*, vol. 34, pp. 429–438.

Bebawi, FF, Campbell, SD & Mayer, RJ 2015, 'Seed bank longevity and age to reproductive maturity of *Calotropis procera* (Aiton) W.T. Aiton in the Dry Tropics of northern Queensland', *The Rangeland Journal*, vol. 37, pp. 239–247.

Bebawi, FF, Campbell, SD & Mayer, RJ 2016, 'Seed bank persistence and germination of chinee apple (*Ziziphus mauritiana* Lam.)', *The Rangeland Journal*, vol. 38, pp. 17–25.

Long, RL, Panetta, FD, Steadman, KJ, Probert, R, Bekker, RM, Brooks, SJ & Adkins, SW 2008, 'Seed persistence in the field may be predicted by laboratory-controlled ageing', *Weed Science*, vol. 56, pp. 523–528.

2. Best practice research on Wet Tropics weeds

Project dates

January 2009 – June 2021

Project team

Melissa Setter and Stephen Setter

Project summary

Weeds are a major threat to the economic productivity and environmental integrity of the Wet Tropics. Many economically significant industries (including agriculture, horticulture and fisheries) are affected if Wet Tropics weeds are not managed effectively. Weed encroachment can decrease biodiversity, placing rare and threatened communities and species at risk. Socially, weed invasion can decrease people's enjoyment of the Wet Tropics (e.g. affecting recreational fishing through the debilitation of fish nurseries, reducing the scenic quality of natural areas, and decreasing the diversity of birds). Both the social and environmental considerations also affect the high tourism value of the region.

There is a paucity of information on several key weed species threatening the Wet Tropics bioregion. Our study species include three Weeds of National Significance (pond apple, hymenachne and bellyache bush) and several others declared under state and/or local government legislation (e.g. Navua sedge, neem and leucaena). Our research targets aspects of ecology and control tools that will support on-ground management, such as seed longevity in soil and water, age to reproductive maturity, rate of spread, dispersal mechanisms and control options developed in herbicide trials.

Collaborators

- Biosecurity officers
- Biosecurity Queensland research officers and centres
- Far North Queensland Regional Organisation of Councils
- Terrain NRM
- Cairns Regional Council
- Cassowary Coast Regional Council
- Tablelands Regional Council
- Etheridge Shire Council
- Mareeba Shire Council
- Douglas Shire Council
- Hinchinbrook Shire Council
- Cook Shire Council

3. Biocontrol of bellyache bush (*Jatropha gossypiifolia*)

Project dates

January 2007 – June 2019

Project team

K Dhileepan, Di Taylor, Liz Snow (until December 2017) and David Fredericks (from August 2017)

Project summary

Bellyache bush (*Jatropha gossypiifolia*), a Weed of National Significance, is a serious weed of rangelands and riparian zones in northern Australia. Bellyache bush has been a target for biocontrol since 1997, with limited success to date. Surveys in Mexico, central and northern South America, and the Caribbean resulted in the release of the seed-feeding jewel bug (*Agonosoma trilineatum*) in 2003, which failed to establish. A leaf rust (*Phakopsora arthuriana*), a leaf-miner (*Stomphastis* sp.), a leaf and shoot-tip webber (*Sciota divisella*) and a gall midge (*Prodiplosis longifila*) have been identified as prospective biocontrol agents. Host-specificity testing of the leaf rust is nearing completion. We have completed host-specificity testing of the leaf-miner and have submitted an application seeking its approval for field release. In view of non-target feeding and development in host-specificity tests in quarantine, we have suspended further work on the Jatropha webber and have terminated the quarantine colony. Future research will focus on the identification and preliminary host-specificity testing of a gall midge from Bolivia and a leaf-feeding midge from Paraguay.

Jatropha rust

The Jatropha rust has been tested for host specificity against 42 non-target species under quarantine conditions at CABI (United Kingdom). Three potentially susceptible Australian native species have been further assessed through dose-response experiments and field host-range testing in Trinidad. Two of these three species, *Aleurites moluccana* and *A. rockinghamensis*, are not considered to be part of the field host range of the rust. The third species, *Beyeria viscosa*, might come under attack in a field situation; however, the rust is unlikely to sustain itself on this Australian native plant.

Studies to determine the life cycle of the Jatropha rust are now the main focus of our work, which aims to confirm whether the rust can complete its development on just bellyache bush, or whether it needs an additional host. To answer this question, teliospores (which are in a dormant state when produced on *J. gossypiifolia*) need to germinate, so that we can assess subsequent basidiospore infection. We have trialled several methods of inducing teliospore germination (including exposure to ultraviolet light, submersion in water and alternating periods of wetting and drying), but these have only been partly successful, with germination of teliospores occurring infrequently. Experiments are currently underway to determine more suitable and reliable methods of spore conditioning.

Jatropha leaf-miner

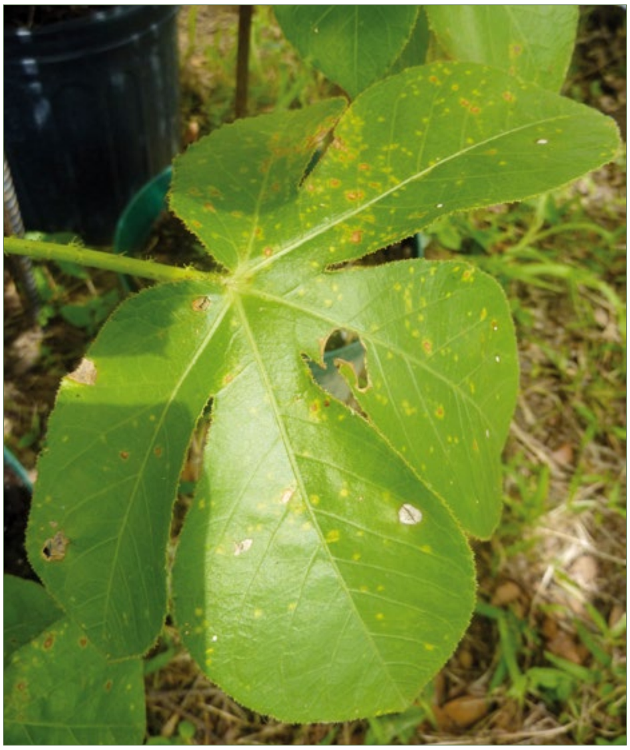
The Jatropha leaf-miner (*Stomphastis* sp.) was imported from Peru and a colony was established in quarantine in November 2014. We have completed no-choice host-specificity testing of Jatropha leaf-miner on 48 test plant species. Adults laid eggs on numerous non-target species, but larval development occurred on only bellyache bush and its congener physic nut (*J. curcas*). In choice oviposition trials, the females laid eggs equally on both bellyache bush and physic nut. Approximately 80% of eggs develop into adults on each of these species. Physic nut, native to tropical America, is a declared weed in Western Australia and the Northern Territory. It is also an approved target for biocontrol. Test results provide strong evidence that the leaf-miner is highly host specific and is suitable for release in Australia. We have submitted an application seeking approval from the relevant regulatory authorities in Australia to release the leaf-miner.

Jatropha webber

The Jatropha webber *Sciota divisella* (Lepidoptera: Pyralidae) was imported into quarantine in 2015 and a colony was established. We have fully completed host-range testing on 17 species with 5 replications each, on 2 species with 4 replications each, and on 16 species with 3 replications each. Testing is partly completed on 6 species (1–2 replications each). An additional 12 species are yet to be tested. In no-choice larval development tests, full larval development occurred on 7 non-target species—5 of these are exotics (*J. curcas*, *J. podagrica*, *Euphorbia neriifolia*, *E. grantii* and *Manihot esculenta*), and 2 are Australian natives (*Macaranga tanarius* and *E. plumerioides*). In both no-choice and choice oviposition trials, egg laying was seen on non-target species. In view of non-target larval feeding and oviposition, we discontinued further screening of test plants and terminated the Jatropha webber colony in quarantine.

Jatropha gall midge

A gall midge (*Prodiplosis longifila*) induces rosette galls in shoot-tips, emerging leaves, petioles and stems, resulting in shoot-tip dieback on *J. clavuligera* in Bolivia. A morphologically similar midge species (*P.* not *longifila*) occurs on *J. gossypiifolia* in Paraguay, feeding on leaves and not inducing galls. To resolve the taxonomic status of the two morphologically similar species with distinct feeding habits, surveys were conducted in 32 sites in Paraguay and Bolivia. Larvae of the gall-inducing midge from Bolivia and the leaf-feeding midge from Paraguay were exported to Argentina for adult emergence. Adults and larvae of the two populations of midges from Argentina have been sent to Adelaide for morphological and molecular taxonomic assessment.



Jatropha rust on bellyache bush

Collaborators

- Marion Seier and Kate Pollard, CABI (United Kingdom)
- Guillermo Cabrera Walsh and Marina Oleiro, Fundación Para El Estudio De Especies Invasivas (Buenos Aires, Argentina)
- Peter Kolesik, Bionomics (Adelaide)
- A Balu, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)

Key publications

Dhileepan, K, Neser, S & De Prins, J 2014, 'Biological control of bellyache bush (*Jatropha gossypiifolia*) in Australia: South America as a possible source of natural enemies', *Proceedings of the XIV international symposium on biological control of weeds*, Kruger National Park, South Africa, pp. 5–10.

Heard, TA, Dhileepan, K, Bebawi, F, Bell, K & Segura, R 2012, '*Jatropha gossypiifolia* L.—bellyache bush', in M Julien, RE McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 324–333.

4. Biocontrol of prickly acacia (*Vachellia nilotica* ssp. *indica*)

Project dates

January 2007 – June 2020

Project team

K Dhileepan, Di Taylor and Boyang Shi

Project summary

Prickly acacia is a Weed of National Significance and a target for biocontrol, but with limited success to date. Based on the field host range in India, a scale insect (*Anomalococcus indicus*), a green leaf-webber (*Phycita* sp.) and a leaf weevil (*Dereodus denticollis*) were brought into Australian quarantine for host-specificity tests. However, they were either not sufficiently host specific for release in Australia or proved difficult to rear in quarantine. With no other prospective agents available from India, our search effort for new biocontrol agents was redirected to Ethiopia and Senegal. A gall thrips and a gall mite from Ethiopia and a gall fly from Senegal were identified as prospective biocontrol agents for prickly acacia and host-specificity testing of these agents is in progress.

Scale insect

We have completed the quarantine testing of the scale insect *A. indicus*, sourced from India, and terminated the scale insect colony in quarantine in June to free up space for other projects. In no-choice tests involving 84 test plant species, development of *A. indicus* females to reproductive maturity occurred on 17 of the non-target species. This may be an artefact of laboratory conditions, as this insect is known to be host specific under field conditions in India. Therefore, choice trials involving non-target tests plants on which the scale completed development in quarantine in Australia commenced at the Institute of Forest Genetics and Tree Breeding in India in 2014. All prickly acacia test plants became infested with the scale insect. In contrast, the scale insect was not recorded on any of the non-target plants (*Neptunia major, Acacia irrorata, A. cardiophylla, A. decurrens* and *A. filicifolia*). The trial is continuing.

Native range surveys

In Senegal, a gall thrips (*Acaciothrips ebneri)*, two gall mites (*Aceria* spp.) and a stem-galling fly (*Notomma mutilum*) were identified as prospective biocontrol agents for prickly acacia. The gall thrips, the two gall mites and the stem-galling fly were found only on prickly acacia and not on other *Vachellia*, *Acacia* and *Senegalia* species co-occurring with prickly acacia. The gall fly was exported into quarantine in Brisbane for colony establishment and host-specificity testing. The gall mites have been exported to Turkey for specialist taxonomic identification. In Ethiopia, a gall thrips (*A. ebneri*) and gall mites (*Aceria* spp.) were found only on prickly acacia and not on other closely related, co-occurring *Vachellia* species.

Gall thrips

A colony of the gall thrips (*A. ebneri*) sourced from Ethiopia has been established in quarantine at the Ecosciences Precinct in Brisbane. Longevity studies and host-specificity tests are in progress. In quarantine, generation time is 4–5 weeks and adults can live for 2–3 months. We conducted no-choice host-specificity tests for 60 non-target test plant species. Adult thrips survived longer on *Vachellia* species than on other non-target test plant species, but so far there has been no evidence of gall induction, egg laying or reproduction on any of the non-target test plant species. In addition, we screened five subspecies of *Vachellia nilotica* and found that thrips lay eggs and form galls on subspecies *indica* and *cupressiformis* (with necklace-shaped fruits), but not on *adstringens*, *kraussiana* and *tomentosa*.

Gall mite

One species of gall mite (*Aceria* sp. type-3) from Ethiopia was imported into quarantine in the Agricultural Research Council Plant Protection Research Institute (ARC-PPRI) in Pretoria, South Africa. A colony has been established on potted Australian prickly acacia plants (grown from seeds sourced from Australia). Potted plants raised from seeds of 63 species of *Acacia*, *Vachellia* and other closely related test plant species sourced from Australia, Ethiopia, Senegal and South Africa are being used in no-choice host-specificity tests in quarantine in ARC-PPRI. In no-choice tests, the gall mites induced galls on the Australian prickly acacia (*Vachellia nilotica* ssp. *indica*) and not on other *V. nilotica* subspecies or other closely related *Vachellia* species sourced from Ethiopia, Senegal and South Africa. The preliminary results indicate that the gall mite is highly host specific to subspecies level. Host-specificity tests for the other test plants will commence soon. The seeds of 15 Australian native test plants (exported from Australia) have been germinated and maintained in a glasshouse in Addis Ababa, Ethiopia, for host-specificity tests. No-choice host-specificity tests for other gall mite species will be conducted once the test plants have grown to the required size (60–80 cm tall).

Gall fly

Over 800 stems cuttings with stem galls of a gall fly (*Notomma mutilum*) were collected in Senegal and imported into quarantine at the Ecosciences Precinct in October 2017 for colony establishment and host-specificity testing, but no flies were recovered. A second collection (of over 700 stem cuttings) was imported into quarantine in April 2018. Emergence of adults commenced from late May and continued until early July. We transferred emerging adults into insect-proof cages with potted prickly acacia plants with new shoots for egg laying and gall development. So far, 243 adult flies have emerged from the field-collected galls, and 41 plants have been exposed to gall flies for oviposition. There is evidence of gall initiation in some of the prickly acacia plants exposed to the gall flies in quarantine.

Prickly acacia at Bowen

Collaborators

- A Balu, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Anthony King, Ayanda Nongogo and Charnie Craemer, ARC-PPRI (Pretoria, South Africa)
- Mindaye Teshome, Forestry Research Centre (Addis Ababa, Ethiopia)
- Nathalie Diagne, Senegalese Institute of Agricultural Research, Centre National de Researches Agronomique (Bambey, Senegal).
- Ocholi Edogbanya, Department of Biological Sciences, Ahmadu Bello University (Zaria, Nigeria)
- Sebahat Ozman Sullivan, Ondokuz Mayis University (Turkey)

Key publications

Dhileepan, K, Taylor, DBJ, Lockett, CJ, Balu, A, Seier, M, Murugesan, S, Tanner, RA, Pollard, KM, Kumaran N & Neser, S 2014, 'Biological control of prickly acacia (*Vachellia nilotica* subsp. *indica*): current research and future prospects', *Proceedings of the XIV international symposium on biological control of weeds*, Kruger National Park, South Africa, pp. 21–30.

Dhileepan, K 2009, '2. *Acacia nilotica* ssp. *indica*', in R Muniappan, DVP Reddy & A Raman (eds), *Weed biological control with arthropods in the tropics: towards sustainability*, Cambridge University Press, United Kingdom, pp. 17–37.

5. Biocontrol of invasive vines (*Dolichandra unguis-cati* and *Anredera cordifolia*)

Project dates

July 2001 – June 2021

Project team

K Dhileepan, Di Taylor, David Fredericks, Liz Snow and Segun Osunkoya

Project summary

Cat's claw creeper and Madeira vine are Weeds of National Significance in Australia. Biocontrol is the most cost-effective option for managing both weeds. Biocontrol of cat's claw creeper commenced in 2001 and since then, three agents—a leaf-sucking tingid (*Carvalhotingis visenda*), a leaf-tying moth (*Hypocosmia pyrochroma*) and a leaf-mining beetle (*Hedgwigiella jureceki*)—have been released in the field. All three agents have established but the introduced range and abundance of these agents vary widely. Our current research focus is on monitoring the establishment and further spread of the leaf-tying moth and the leaf-mining beetle.

Cat's claw creeper, being a perennial vine with abundant subterranean tuber reserves, will require multiple agents attacking various parts of the plant for effective control. Additional agents identified for host testing are a leafhopper and three plant pathogens.

Biocontrol of Madeira vine commenced in 2008 and resulted in the release of one agent, a leaf-feeding beetle (*Plectonycha correntina*). The beetle has been seen widely in many of the release sites, but there is no evidence of any widespread damage and dispersal. There are no other prospective agents available for Madeira vine in the native range.

Leaf-tying moth

The leaf-tying moth was field released from 2007 to 2011. The larvae feed destructively on leaves, by tying leaves together with silk, leading to the creation of silken tunnels. Evidence of field establishment was first seen in 2012 at two riparian sites (Boompa and Coominya) and one non-riparian site (Oxley) in south-eastern Queensland. Since 2012, the moth has spread along the local creeks and has established in areas surrounding the release site. We conducted surveys at 89 sites (28 release sites and 61 non-release sites surrounding the release sites) over January–March 2018. Field establishment and local spread of the leaf-tying moth was confirmed in 22 sites (as evident from leaf-tying damage symptoms and by recovered developing larvae), all in the Boompa, Coominya and Oxley areas. Leaf-tying moth damage was observed as high as 15 m in the trees. Larval recoveries confirmed that the damage symptoms are from the current season and allowed tentative identification of the larval stage (to assess whether the moth has overlapping or multiple generations). Fresh leaf-tying moth damage and larval recoveries were made in December 2017 and continued until March 2018. A CLIMEX model incorporating the diapause behaviour of the moth has also been developed, to predict its potential distribution. We will continue to monitor the spread and damage levels.

Leaf-mining beetle

The leaf-mining beetle was field released from 2012 to 2017. Both the larvae and adults are very damaging—larvae mine within leaves and the adults feed on young leaves. Mass rearing has largely finished, with a small colony being kept to supply the numerous community groups who are beginning their own mass rearing and field release of the beetle. We revisited most of the release sites in late 2017 to monitor the establishment and spread of the agent. In each site, we spent 10 minutes counting the number of adults, leaf-mines with larvae and pupal discs. The beetle continues to spread from release sites to nearby areas. Establishment of the beetle (as evident from leaf-mining of larvae, pupal discs, and adults congregating on young leaves) was recorded in 90% of the 69 release sites and many surrounding non-release sites. Through more systematic studies, we will monitor the establishment, spread and damage levels of the leaf-mining beetle at select release sites in south-eastern Queensland.

Cat's claw creeper leafhopper

A leafhopper (*Neocrassana undata*) collected on long-pod varieties of cat's claw creeper in Brazil is a potential biocontrol agent for the long-pod form of cat's claw creeper in Queensland. Both the adults and nymphs feed gregariously on the leaves, but the adults and later instars are also able to feed on petioles and young stems. Feeding by the leafhopper results initially in leaf chlorosis, followed by the development of red lesions and eventually leaf curling around feeding sites. The leafhopper was imported into the quarantine facility at the Ecosciences Precinct from a quarantine facility in Pretoria, South Africa, in June 2018. We will commence host-specificity tests when a colony of the leafhopper is established in quarantine.

Plant pathogens

A leaf-spot pathogen (*Cercosporella dolichandrae*) causing necrotic spots and premature leaf abscission and two rust fungi—a rust-gall (*Uropyxis rickiana*) and a leaf-rust (*Prospodium macfadyena*)—have been identified as prospective biocontrol agents for cat's claw creeper in Australia. Host-specificity testing of two of these (the leaf-spot pathogen and the rust-gall) will be undertaken in quarantine by CABI in the United Kingdom over 2018–2021. The leaf-spot pathogen sourced from South Africa has been exported to CABI and a culture has been established and maintained in quarantine. The two rust pathogens will be sourced from Brazil. Seeds of cat's claw creeper (both long- and short-pod forms) and seeds and bare-rooted plants of various test plants have been exported to the United Kingdom for host-specificity testing.

Cat's claw creeper leaf-tying moth

Collaborators

- Seqwater
- Tanya Scharaschkin, Queensland University of Technology
- Anthony King, ARC-PPRI (Pretoria, South Africa)
- Marion Seier and Kate Pollard, CABI (United Kingdom)
- Robert Barreto, Universidade Federal de Viscosa (Brazil)
- Queensland Department of Environment and Science

Key publications

Dhileepan, K, Taylor, D, Treviño, M & Lockett, C 2013, 'Cat's claw creeper leaf-mining beetle *Hylaeogena jureceki* Obenberger (Coleoptera: Buprestidae), a host specific biological control agent for *Dolichandra unguis-cati* (Bignoniaceae)', *Australian Journal of Entomology*, vol. 52, pp. 175–181.

Dhileepan, K 2012, '*Macfadyena unguis-cati* (L.) A.H. Gentry—cat's claw creeper', in M Julien, RE McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 351–359.

6. Biocontrol of Navua sedge (*Cyperus aromaticus*): feasibility studies

Project dates

July 2017 – June 2019

Project member

K Dhileepan

Project summary

Navua sedge (*Cyperus aromaticus*), a perennial grass-like sedge, is an extremely aggressive weed affecting beef, dairy and sugarcane industries in the Queensland Wet Tropics. The sedge is unpalatable, and can form dense stands, replacing palatable tropical pasture species.

In grazing areas, current management options are mechanical and chemical, which are expensive and offer short-term relief, but are not practical for large areas. Biocontrol of Navua sedge has not been explored to date. This project explores the feasibility of classical biocontrol for Navua sedge by surveying the native range in equatorial Africa for specialist, host-specific natural enemies. Native range surveys will focus initially on equatorial eastern Africa (Kenya and Tanzania), because of ease of access and local scientific support. If promising agents are found, we will pursue detailed host-specificity tests. We may also undertake future surveys in western Africa.

Native range distribution

We sourced records of Navua sedge in the native range from herbariums in the United Kingdom, Kenya, Tanzania and Nigeria. From these, we prepared a native range distribution map for Navua sedge. We are attempting to source records for other equatorial African countries.

Native range survey

We undertook surveys at 44 sites in Kenya and 31 sites in Tanzania, in partnership with research collaborators from the University of Southern Queensland and herbariums in Kenya and Tanzania. We sampled 36 species of sedges (including Navua sedge) and collected rust pathogens on 11 sedge species, smut disease on 6 sedge species and leaf-spot disease on 2 sedge species. On Navua sedge, a smut pathogen affecting flower heads and a leaf-spot pathogen causing leaf necrosis were identified as prospective biocontrol agents. These pathogens were not seen on other co-occurring *Cyperus* species, suggesting that the pathogens are likely to be host specific. No rust pathogen was found on Navua sedge, and no insects or insect damage were seen on Navua sedge. A flower-head-feeding thrips was collected on another sedge species, and stem-borers were collected on two other sedge species.

Specimens of over 36 sedge species were collected and lodged in the East African Herbarium in Nairobi. Duplicates will be sent to the National Herbarium of Tanzania, Kew Gardens and the Queensland Plant Pathology Herbarium for the identification of both sedges and pathogens by molecular methods. Dried leaf samples of 36 sedge species from Kenya and Tanzania were imported into Australia for molecular studies.

Future research

The survey, though preliminary, shows that the prospects for finding specialist pathogens for the biocontrol of Navua sedge are promising. Future research will focus on identification of the pathogens as a first step to ascertain their host specificity.

Previous records of rusts on Navua sedge in Gabon and Nigeria suggest that future surveys in western Africa could be fruitful. We will prepare an application seeking approval to declare Navua sedge as a biocontrol target.

Surveying Navua sedge in eastern Africa for prospective biocontrol agents

Collaborators

- Professor Roger Shivas, University of Southern Queensland
- Dr Mutuku Musili and Frederick Munyao Mutie, East African Herbarium (Kenya)
- Dr John Elia Ntandu, National Herbarium of Tanzania
- Ocholi Edogbanya, Ahmadu Bello University (Zaria, Nigeria)
- Dr Isabel Larridon, Kew Gardens (United Kingdom)
- Dr Alistair McTaggart (The University of Queensland)

Key publications

Vitelli, JS, Madigan, BA & van Haaren, PE 2010, 'Control techniques and management strategies for the problematic Navua sedge (*Cyperus aromaticus*)', *Invasive Plant Science and Management*, vol. 3, pp. 315–326.

7. Biocontrol of parthenium (*Parthenium hysterophorus*)

Project dates

July 2004 – June 2019

Project team

K Dhileepan, Segun Osunkoya, Jason Callander, Christine Perrett, Boyang Shi and Kelli Pukallus

Project summary

Parthenium (*Parthenium hysterophorus* L.), a noxious weed of grazing areas in Queensland, is a Weed of National Significance in Australia. Biocontrol of parthenium has been in progress since the mid-1980s. Eleven biocontrol agents (nine insect species and two rust pathogens) have been released against parthenium in Australia. Most of these agents have become established and have proven effective against the weed in central Queensland.

Parthenium is spreading further south and is emerging as a serious weed in southern Queensland, where the biocontrol agents have not yet spread. We have initiated a program to redistribute these agents from central Queensland to the south and south-east of the state. Also, effective biocontrol agents were also exported into India and South Africa.

Biocontrol agents in northern Queensland

We conducted surveys in May 2018, but only in two (Cardigan Station and Bivouac Junction) of the three regular sites because there was no green parthenium at the Plain Creek site. In both Bivouac Junction and Cardigan Station, the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) and the stem-galling moth (*Epiblema strenuana*) were abundant. The root-feeding clear-wing moth (*Carmenta ithacae*), the sap-feeding planthopper (*Stobaera concinna*) and the leaf-mining moth (*Bucculatrix parthenica*) were also seen in both sites. However, the seed-feeding weevil (*Smicronyx lutulentus*) was found only in Cardigan Station. There was no evidence of the leaf-feeding beetle (*Zygogramma bicolorata*) or the winter rust (*Puccinia abrupta* var. *partheniicola*) at either site.

Biocontrol agents in central Queensland

We conducted surveys at 19 sites (Gracemere, Mount Hay, Wycarbah, Aphis Creek, Lotus Creek, Carfax, Clermont, Morebridge, Gaylong, Gordon Road, Sandhurst Bridge, Wyntoon, May Downs, Old Orion Road, Rolleston, Bauhinia, Consuelo, Moolayember Creek and Hutton Creek) in November 2017, and in January, February, April and May 2018. The seed-feeding weevil (*S. lutulentus*), the stem-boring weevil (*Listronotus setosipennis*) and the leaf-mining moth (*Bucculatrix parthenica*) were recovered from about half the sites with low to moderate densities. The stem-galling moth (*E. strenuana*), the root-feeding clear-wing moth (*C. ithacae*) and the summer rust (*P. xanthii* var. *parthenii-hysterophorae*) were prevalent in the majority of the sites and in high densities. The stem-boring moth (*Platphalonia mystica)* and the leaf-feeding beetle (*Z. bicolorata*) were not recovered from any sites in central Queensland.

Biocontrol agent redistribution in southern Queensland

In consultation and collaboration with community and local government groups, we identified 30 parthenium-infested sites in southern and south-eastern Queensland for release of biocontrol agents. Parthenium-infested sites in North Burnett have also been identified for monitoring and evaluating the impact of biocontrol. Glasshouse colonies of the summer rust were established for mass rearing and field release. Approximately 4300 field-collected *Smicronyx* weevils and about 4300 field-collected plants (infested with *Listronotus* and *Carmenta* larvae) from central Queensland were released into southern Queensland. Winter rust (68 rust-infected plants and over 2550 rust-infected leaves) and summer rust (304 rust-infected plants and about 700 rust-infected leaves) were released at over 20 sites in southern and south-eastern Queensland. Surveys in southern Queensland (e.g. Cedar Vale, Kamorooka, Womillia Creek, Bowood and Amby–Springfield Road) and in south-eastern Queensland (e.g. Kilcoy, Junction View, Helidon Spa, Somerset, Biggenden, Mundubbera and Monto) recorded widespread establishment of the *Epiblema* moth, the *Bucculatrix* moth, the winter rust, the summer rust and the *Smicronyx* weevil. The *Zygogramma* beetle has established at some sites, although densities are very low. *Carmenta* moth and *Listronotus* weevil have been recovered at four sites in southern Queensland.

Biocontrol agent export to other countries

Field-collected *Smicronyx* adults were exported into a quarantine facility at the Indian Council for Agricultural Research National Bureau of Agricultural Insect Resources (ICAR-NBAIR, Bengaluru) for colony establishment and host-specificity tests. Also, field-collected *Carmenta* moth and *Epiblema* moth were exported into a quarantine facility in South Africa (ARC-PPRI, Hilton) for colony establishment and host-specificity tests.

Collaborators

- Steve Adkins, The University of Queensland
- Rachel McFadyen (Brisbane)
- S Raghu, CSIRO Ecosystem Dynamics
- Lorraine Strathie, ARC-PPRI (Hilton, South Africa)
- Sreerama Kumar Prakya, ICAR-NBAIR (India)
- Kel Woodall, RAPID Workforce (Mitchell)
- Tom Garrett and Holly Hosie, Queensland Murray–Darling Committee
- Ross Bigwood and Bruce Lord, Healthy Land and Water
- Pat Ryan, Junction View Pest Management Group
- Glen Proctor, Jenny Voigt, Neale Jensen and John Pieters, North Burnett Regional Council
- Eric Dyke, Bundaberg Regional Council
- Trevor Armstrong, Oxley Creek Catchment Association
- Femi Akinsami, The University of Queensland and Queensland Alliance for Agriculture and Food Innovation

Key publications

Dhileepan, K & McFadyen, RE 2012, '*Parthenium hysterophorus* L.—parthenium', in M Julien, RE McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 448–462.

Dhileepan, K 2009, 'Managing *Parthenium hysterophorus* across landscapes: limitations and prospects', in S Inderjit (ed.), *Management of invasive weeds*, Invading Nature—Springer series in invasion ecology, vol. 5, Springer Science, pp. 227–260.

Dhileepan, K & Strathie, L 2009, '20. *Parthenium hysterophorus*', in R Muniappan, DVP Reddy & A Raman (eds), *Weed biological control with arthropods in the tropics: towards sustainability*, Cambridge University Press, United Kingdom, pp. 272–316.

8. Biocontrol of parkinsonia (*Parkinsonia aculeata*)

Project dates

March 2013 – September 2018

Project team

Kelli Pukallus, Judy Clark, Joshua Nicholls and Dannielle Brazier

Project summary

This collaborative project with CSIRO involves the mass rearing, releasing and monitoring of *Eueupithecia cisplatensis* (UU) and *Eueupithecia vollonoides* (UU2) for the biocontrol of parkinsonia (*Parkinsonia aculeata*) within Queensland. UU and UU2 are leaf-feeding geometrid caterpillars from Argentina; they defoliate the leaflets from the plant, which weakens and reduces flower and seed production.

The Tropical Weeds Research Centre commenced releases in early 2013 at sites encompassing nine local government areas within Queensland. Releases commenced into parts of the Northern Territory and Western Australia in late 2016. To date, releases of UU have been made at 113 sites in these three jurisdictions and comprised 3270 adults, 504 600 larvae/eggs and 325 413 pupae (13 574 into Western Australia and 10 322 into the Northern Territory). Also, 25 786 UU2 pupae were released at 17 sites (3497 into Western Australia). The release sites are in various terrains and climatic conditions such as drier inland areas, open woodlands, gullies, coastal areas and riparian areas on private grazing properties, national parks, local government land reserves and mining leases.

Establishment of UU has been recorded at more than half of the release sites within Queensland. In most cases it has spread more than 5 km from the release site, but in some cases the spread has extended to more than 20 km from the release site. Populations have persisted throughout the year and continue to spread into new parkinsonia infestations.

Collaborators

- Raghu Sathyamurthy, Gio Fichera and Andrew White, CSIRO (Brisbane)
- Burdekin Shire Council
- Isaac Regional Council
- Central Highlands Regional Council
- Charters Towers Regional Council
- Townsville City Council
- Capricorn Catchments Inc.
- Fitzroy Basin Association Inc.
- CHHRUP (Emerald)
- Queensland Department of Agriculture and Fisheries and Queensland Parks and Wildlife Service regional staff
- Western Australia Department of Agriculture and Food
- Northern Territory Department of Land Resource Management

9. Biocontrol of *Mikania micrantha*

Project dates

July 2014 – June 2018

Project team

Michael Day and Natasha Riding

Project summary

Mikania micrantha was first reported in Queensland in 1998 and is also present in the Australian territories of Christmas Island and the Cocos Islands. Mikania is the target of a nationally cost-shared eradication program. However, recent cyclones have hampered the eradication program and the latest review of the program recommended that biocontrol options should be investigated.

The rust *Puccinia spegazzinii* is deemed host specific, having been tested in five countries against a total of 273 species, representing 73 families, including 87 species in the Asteraceae family, 21 species in the Eupatorieae family and 11 species of *Mikania*. The rust was subsequently released in India, China, Taiwan, Papua New Guinea (PNG), Fiji, Vanuatu, the Cook Islands and more recently Palau. It has established in Taiwan, PNG, Fiji, Vanuatu and the Cook Islands. It has also been reported in the Solomon Islands, although no deliberate release was conducted there.

In PNG, field monitoring and laboratory trials have shown that the rust suppresses the growth of mikania. In both PNG and Vanuatu, where it has been widely released, anecdotal information suggests that mikania is beginning to be suppressed and its flowering reduced. The rust was imported into quarantine at the Ecosciences Precinct in Brisbane and was tested against 14 species in the tribe Eupatorieae and 6 species in the tribe Heliantheae. Pustule development and infection occurred on mikania only; no other plant species were affected. An application seeking its release in Australia has been drafted, and we will be submitting it to the federal Department of Agriculture and Water Resources and Department of the Environment and Energy.

Collaborators

- CABI (United Kingdom)
- Biosecurity Vanuatu
- Ministry of Natural Resources (Palau)
- National Agricultural Research Institute (PNG)
- National Agriculture Quarantine and Inspection Authority (PNG)
- Yunnan Academy of Agricultural Sciences (China)
- Kerala Forest Research Institute (India)

Key publications

Day, M 2012, '*Mikania micrantha* Kunth—mile-a-minute', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 368–372.

Day, MD, Clements, DR, Gile, C, Senaratne, KADW, Shen, S, Weston, LA & Zhang, F 2016, 'Biology and impacts of Pacific islands invasive species: *Mikania micrantha* Kunth (Asteraceae)', *Pacific Science*, vol. 70, pp. 257–285.

Day, MD, Kawi, AP & Ellison, CA 2013, 'Assessing the potential of the rust fungus *Puccinia spegazzinii* as a classical biological control agent for the invasive weed *Mikania micrantha* in Papua New Guinea', *Biological Control*, vol. 67, pp. 253–261.

Day, MD, Kawi, AP, Fidelis, J, Tunabuna, A, Orapa, W, Swamy, B, Ratutini, J, Saul-Maora, J & Dewhurst, CF 2013, 'Biology, field release and monitoring of the rust *Puccinia spegazzinii* de Toni (*Pucciniales: Pucciniaceae*), a biocontrol agent of *Mikania micrantha* Kunth (Asteraceae) in Papua New Guinea and Fiji', *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, West Virginia, pp. 211–217.

10. Biocontrol of *Cylindropuntia* spp.

Project dates

March 2009 – June 2018

Project team

Michael Day, Peter Jones, Kerri Moore (until August 2017), Tamara Taylor and Saku Muthuthantri

Project summary

Cylindropuntia cactus species are native to tropical America. The group includes *Cylindropuntia kleiniae* and *C. leptocaulis* (pencil cactus), both of which are prohibited weeds in Queensland, and *C. fulgida* (coral cactus), *C. imbricata* (devil's rope pear), *C. pallida* (Hudson pear), *C. prolifera* (jumping cholla), *C. spinosior* (snake cactus) and *C. tunicata* (Hudson pear), which are restricted weeds in Queensland.

A biotype of *Dactylopius tomentosus* was released in Australia in 1925 to control *C. imbricata*, but this biotype does not heavily impact other *Cylindropuntia* species.

The *D. tomentosus* ('cholla' biotype), which proved very effective in South Africa, was approved for field release against *C. fulgida* in December 2015. To date, it has been released at over 35 sites in Queensland, New South Wales, South Australia and Western Australia and has established at 20 sites. At 2 monitoring sites, coral cactus was controlled by the cochineal in 18 months.

Additional biotypes have now been released against Hudson pear, devil's rope pear and snake cactus. These sites are currently being monitored for establishment and impact of the cochineal. Field releases of cochineal to target jumping cholla and the remaining *Cylindropuntia* species will commence shortly.

Collaborators

- New South Wales Department of Primary Industries
- Dr Helmuth Zimmermann (South Africa)
- Local governments in central and western Queensland.
- Desert Channels Queensland
- Southern Gulf NRM
- South West NRM
- Condamine Alliance
- New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce
- Western Local Land Services (New South Wales)
- Castlereagh Macquarie County Council (New South Wales)
- Western Australia Department of Agriculture and Food
- South Australia Department for Environment and Water
- South Australia Department of Primary Industries and Regions
- Adelaide and Mount Lofty Ranges Natural Resources Management Board (South Australia)

Dactylopius on *Cylindropuntia fulgida* near Longreach, January 2017

Dactylopius on *Cylindropuntia fulgida* near Longreach, March 2018

Key publications

Holtkamp, RH 2012, '*Cylindropuntia imbricata* (Haw.) F.M. Knuth - rope pear *Cylindropuntia rosea* (DC.) Backeb. - Hudson pear', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 198–202.

Mathenge, CW, Holford, P, Hoffmann, JH, Spooner-Hart, R, Beattie, GAC & Zimmermann, HG 2009, 'The biology of *Dactylopius tomentosus* (Hemiptera: Dactylopiidae)', *Bulletin of Entomological Research*, vol. 99(6), pp. 551–559.

Jones, PK, Holtkamp, RH, Palmer, WA & Day, MD 2015, 'The host range of three biotypes of *Dactylopius tomentosus* (Lamarck) (Hemiptera: Dactylopiidae) and their potential as biological control agents of *Cylindropuntia* spp. (Cactaceae) in Australia', *Biocontrol Science and Technology*, vol. 25, pp. 613–628.

Jones, PK, Holtkamp, RH & Day, MD 2016, 'The host range of four new biotypes of *Dactylopius tomentosus* (Hemiptera: Dactylopiidae) from southern USA and their potential as biological control agents of *Cylindropuntia* spp. (Cactaceae) in Australia: Part II', *Biocontrol Science and Technology*, vol. 26, pp. 1033–1047.

11. Biocontrol of *Lantana camara*

Project dates

July 1996 – June 2018

Project team

Michael Day, Natasha Riding, Kelli Pukallus and Judy Clark (until September 2017)

Project summary

Lantana is a major weed of grazing, forestry and conservation areas. It is found throughout coastal and subcoastal areas of eastern Australia, from the Torres Strait Islands in the north to the Victorian border in the south. Lantana can be controlled using chemicals, machinery and fire but some of these methods are not suitable in forestry or conservation areas or are not cost-effective. Biocontrol is seen as the only viable option in many areas.

Although biocontrol has been in progress in Australia since 1914, recent research has emphasised the need to find agents that damage specific parts of the plant or prefer the climatic regions in which lantana grows. This project has relied on strong overseas collaboration to identify new agents and collaboration with stakeholders in eastern Australia to release agents and monitor their establishment and impact.

The lantana budmite *Aceria lantanae* has been widely field released. Populations have persisted at only a few sites around south-eastern Queensland, but the budmite is becoming abundant in northern Queensland at numerous sites, especially from Charters Towers to Townsville and south to Bowen. It is also found around Kuranda (on the Atherton Tableland) and Cardstone. Field releases of the budmite are continuing.

The herringbone leaf-mining fly *Ophiomyia camarae* is widespread in northern Queensland and is becoming more common in south-eastern Queensland. It has recently been reported in numerous suburbs around Brisbane. Collectively, biocontrol agents have been causing severe defoliation to lantana in many areas of south-eastern Queensland, resulting in reduced number of flowers and seed set.

Aceria lantanae on lantana at Charters Towers

Collaborators

- CABI (United Kingdom)
- ARC-PPRI (South Africa)
- New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce
- Queensland Parks and Wildlife and Department of Agriculture and Fisheries regional staff
- Local governments in coastal and subcoastal Queensland

Key publications

Day, M 2012, '*Lantana camara* L. – lantana', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 334–46.

Day, MD, Broughton, S & Hannan-Jones, MA 2003, 'Current distribution and status of *Lantana camara* and its biological control agents in Australia, with recommendations for further biocontrol introductions into other countries', *Biocontrol News and Information*, vol. 24(3), pp. 63N–76N.

Day, MD, Wiley, CJ, Playford, J & Zalucki, MP 2003, *Lantana: current management status and future prospects*, Australian Centre for International Agricultural Research, Canberra.

12. Biocontrol of *Chromolaena odorata*

Project dates

July 2011 – June 2018

Project team

Michael Day and Natasha Riding

Project summary

Chromolaena odorata was first reported in Queensland in 1994 and is also present in the Australian territories of Christmas Island and the Cocos Islands. It was the target of a nationally cost-shared eradication program until 2013. However, it was approved as a target for biocontrol in 2011, following several reviews of the program. The host-specificity of the gall fly *Cecidochares connexa* has been tested in 7 countries against a total of 122 species, representing 31 families and including 38 species in the Asteraceae family, of which 6 were in the tribe Eupatorieae.

The gall fly was subsequently released in 12 countries, including PNG, Indonesia, Micronesia and Timor Leste, where it is controlling or aiding the control of *C. odorata*. It was imported into quarantine at the Ecosciences Precinct in February 2012. We tested 18 Eupatridae species in 'choice minus the host plant' trials, with some larvae completing development to adult on *Praxelis clematidea*. Further tests showed that populations of the gall fly could not be sustained on *P. clematidea*. Also, field observations in Palau found no gall formation on *P. clematidea*.

In April 2015, we submitted to the federal Department of Agriculture and Water Resources an application seeking release of the gall fly. After a long hiatus, the department now recommends that the gall fly be approved for release and the submission is on their website for public consultation. Final approval for release is still pending.

Collaborators

- National Agricultural Research Institute (PNG)
- National Agriculture Quarantine and Inspection Authority (PNG)
- Bureau of Agriculture (Palau)
- Australian Department of Agriculture and Water Resources

Key publications

Day, MD, Bofeng, I & Nabo, I 2013, 'Successful biological control of *Chromolaena odorata* (Asteraceae) by the gall fly *Cecidochares connexa* (Diptera: Tephritidae) in Papua New Guinea', *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, West Virginia, pp. 400–408.

Day, MD, Brito, AA, da Costa Guterres, A, da Costa Alves, AP, Paul, T & Wilson, CG 2013, 'Biocontrol of *Chromolaena odorata* in Timor Leste', *Proceedings of the eighth international workshop on biological control and management of* Chromolaena odorata *and other Eupatorieae*, ARC-PPRI, Pretoria, pp. 134–140.

Day, M & McFadyen, RC 2012, '*Chromolaena odorata* (L.) King and Robinson – chromolaena', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 162–169.

Day, MD, Riding, N & Senaratne, KADW 2016, 'The host specificity and climatic suitability of the gall fly *Cecidochares connexa* (Diptera: Tephritidae), a potential biological control agent for *Chromolaena odorata* (Asteraceae) in Australia', *Biocontrol Science and Technology*, vol. 26, pp. 691–706.

13. Biocontrol of mother-of-millions

Project dates

January 2017 – June 2020

Project team

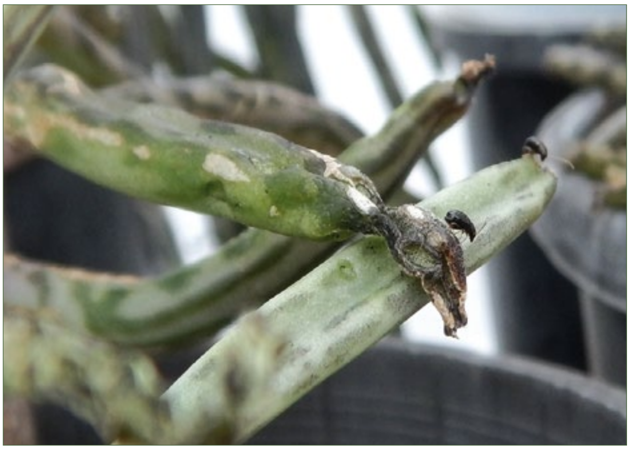
Michael Day, Natasha Riding and Tamara Taylor

Project summary

Mother-of-millions (*Kalanchoe* spp. = *Bryophyllum* spp.) is native to Madagascar and has become a major weed in Queensland and northern New South Wales. Earlier work found four potential agents in Madagascar and host specificity was assessed on two species. These attacked closely related, mostly ornamental plants in several genera. This indicated that off-target impacts were likely, so we applied for field release for one agent, *Osphilia tenuipes*, through the federal *Biological Control Act 1984*, where the benefits and costs of such cases are formally considered. This revealed that further assessment is needed.

Under a new 4-year project, *O. tenuipes* was again collected from Madagascar and imported into a quarantine facility in Orange, New South Wales, where additional host-specificity testing is being conducted. In November 2017, a root-feeding beetle (*Rhembastus* sp.) was imported from Madagascar into quarantine at the Ecosciences Precinct, where it will undergo host-specificity testing.

Rhembastus sp. damage to mother-of-millions



Close-up of *Rhembastus* sp.

Collaborators

- New South Wales Department of Primary Industries
- University of Antananarivo (Madagascar)
- AgriFutures Australia
- Local government and NRM groups

Key publications

Palmer, B & Rafter, M 2012, '*Bryophyllum delagoense* (Ecklon & Zeher) Schinz – mother-of-millions', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 99–107.

Palmer, W & Senaratne, K 2016, 'Assessment of a stenophagous weevil, *Osphilia tenuipes* (Coleoptera: Curculionidae), as a potential biological control agent for weedy *Bryophyllum* spp. (Crassulaceae) in Australia', *Biological Control*, vol. 100, pp. 101–107.

Witt, ABR, McConnachie, AJ, Palmer, WA & Grobbelaar, E 2006, 'Distribution, biology and host range of *Rhembastus* sp. (Coleoptera: Chrysomelidae), a candidate for the biological control of *Bryophyllum delagoense* (Crassulaceae) in Australia', *Biocontrol Science and Technology*, vol. 16(8), pp. 859–869.

14. Biocontrol of giant rat's tail grass

Project dates

January 2017 – June 2020

Project team

Michael Day and Natasha Riding

Project summary

Giant rat's tail grass is the common name for the species *Sporobolus pyramidalis* and *S. natalensis*, which are major weeds in coastal and subcoastal Queensland and northern New South Wales. Current control efforts for weedy *Sporobolus* grasses centre on the use of chemical, mechanical, plant-competition and pasture-management methods. However, there has been limited success in the control of weedy *Sporobolus* grasses, which continue to spread rapidly into new areas. A biocontrol project was implemented in the 1990s but did not result in the release of any biocontrol agents. More recently, biocontrol focused on the indigenous fungus *Nigrospora oryzae*, but it does not appear to be as damaging to giant rat's tail grasses as it is to giant Parramatta grass.

A new 4-year project is exploring options for biocontrol of giant rat's tail grass in South Africa. This project will build on the earlier biocontrol program, which identified several species worth investigating. A doctorate student with Rhodes University is conducting field surveys and assessing potential candidates for their suitability as biocontrol agents. Several stem-boring wasps appear to be damaging to giant rat's tail grass and they show a degree of specificity in the field. More detailed host-specificity studies will be conducted in the laboratory. All insects collected have been curated and have been sent for formal identification.

Sampling giant rat's tail grass for insects and pathogens

Collaborators

- Rhodes University (South Africa)
- AgriFutures Australia
- Bundaberg Regional Council
- Gladstone Regional Council
- HQPlantations
- New South Wales Department of Primary Industries
- Local governments in coastal and subcoastal Queensland

Key publications

Palmer, B 2012, '*Sporobolus* spp. – weedy sporobolus grasses', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 569–575.

Palmer, WA, Yobo, KS & Witt, AB 2008, 'Prospects for the biological control of the weedy sporobolus grasses in Australia', *Proceedings of the 16th Australian weeds conference*, The Weed Society of Queensland, Brisbane, pp. 18–22.

Witt, ABR & McConnachie, AJ 2004, 'The potential for classical biological control of invasive grass species with special reference to invasive *Sporobolus* spp.(Poaceae) in Australia', *XI international symposium on biological control of weeds*, CSIRO Entomology, Canberra, pp. 198–202.

15. Control and ecology of *Stevia ovata*

Project dates

July 2012 – June 2021

Project team

Melissa Setter, Stephen Setter and Simon Brooks

Project summary

While *Stevia ovata* (candy leaf) is recorded only in the southern Atherton Tableland region of northern Queensland, it is deemed such a threat to the area that it has been declared under local law by the Tablelands Regional Council. It is also included in the weed lists from the Far North Queensland Pest Advisory Forum and the Wet Tropics Management Authority and is category 3 restricted biosecurity matter in the Queensland *Biosecurity Act 2014*.

A working group of stakeholders—including local government, state government, energy companies and landholders—requested research into herbicide control of candy leaf, along with studies to determine its ecology. Research has been completed on the weed's germination requirements, age and size at reproductive maturity, seed longevity in soil (in the Wet Tropics and Dry Tropics of northern Queensland) and seed longevity in water. Effective herbicides have been identified for both the high-volume foliar and low-volume, high-concentration (splatter-gun) application techniques.

A pre-emergent herbicide trial using pots containing seeds of candy leaf is nearing completion. Fourteen herbicides are being tested for possible use across different agricultural, amenity and environmental land uses.

Applying herbicide at a research site for *Stevia ovata* using a gas-powered splatter gun

Collaborators

- *Stevia ovata* stakeholder group (includes community members, energy companies, local government)
- Biosecurity officers
- Biosecurity Queensland research officers and centres
- Far North Queensland Regional Organisation of Councils
- Tablelands Regional Council
- Terrain NRM

Key publications

Setter, MJ, Setter, SD, Brooks, SJ & Campbell, SD 2016, '*Stevia ovata*—not so sweet', *Proceedings of the 20th Australasian weeds conference*, Weeds Society of Western Australia, Perth, pp. 13–16.

16. Sicklepod ecology and control

Project dates

January 2016 – June 2021

Project team

Melissa Setter and Stephen Setter

Project summary

Sicklepod (*Senna obtusifolia*) is a serious weed of many parts of northern Queensland (from Cape York to Mackay) and occurs in pastures, crops and corridors such as road and powerline clearings and creek banks. In this project, we focus on three areas of research to improve management tools for sicklepod.

Seed longevity and production

We plan to substantiate some of the ecological information currently being used, in particular the longevity of the seed bank under a range of local environmental conditions, which can greatly influence management decisions. We will also investigate reproductive characteristics such as timing of and age to seeding.

Pre-emergent herbicide efficacy

A number of post-emergent herbicide control options are available for sicklepod, but regional stakeholders have specifically requested that pre-emergent herbicide options be investigated. This is because sicklepod has a relatively short life cycle that occurs during the wet season, when access to plants can be limited. To optimise the effect of pre-emergent residual herbicides, we will investigate the seasonality of seed production and environmental triggers for germination (rainfall and temperature) relative to local conditions.

Low-volume, high-concentration herbicide application

These techniques are particularly suitable for areas with poor vehicle accessibility, and we will test several selected herbicides and possibly different application equipment for their efficacy on sicklepod.

Collecting sicklepod seed near Cooktown

Collaborators

- Biosecurity officers
- Biosecurity Queensland research officers and centres
- Cape York NRM
- Local governments in northern Queensland (e.g. Cook Shire Council)
- Queensland Parks and Wildlife Service
- Landowners and pastoralists
- Herbicide manufacturers

17. Aquatic weeds of northern Australia—ecology and control

Project dates

January 2015 – June 2021

Project team

Melissa Setter and Stephen Setter

Project summary

Aquatic weeds are a burgeoning problem with the increase in commercial trade of aquatic plants, particularly via the internet. Several escaped aquarium plants are particularly problematic in the Wet Tropics, and have potential distributions across large parts of northern Australia. These include hygrophila (*Hygrophila costata*), bogmoss (*Myacca fluviatilis*) and Amazonian frogbit (*Limnobium laevigatum*).

Through this project, we will address a number of ecological questions to improve management of current infestations and predict/restrict further infestations. We are also investigating control options. Specifically, we are researching:

- seed and vegetative reproduction abilities in regional populations of hygrophila
- herbicide control of bogmoss
- seed viability and longevity in regional populations of Amazonian frogbit.

Initial results showed that stem fragments of hygrophila were able to float and survive for 3 weeks in fresh or brackish water and 2 weeks in salt water, demonstrating the potential for dispersal via this pathway. Also, Amazonian frogbit was found to have viable seed in regional populations.

Collecting Amazonian frogbit near Mareeba

Collaborators

- Biosecurity officers
- Biosecurity Queensland research officers and centres
- Far North Queensland Regional Organisation of Councils
- Terrain NRM
- Cairns Regional Council
- Cassowary Coast Regional Council
- Hinchinbrook Shire Council
- Russell Landcare and Catchment Group
- Jaragun Pty Ltd

Key publications

Setter, MJ, Setter, SD & Styman, DT 2017, 'Survival and buoyancy of *Hygrophila costata* stem fragments in salt, brackish and fresh water', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Setter, SD, Graham, Michael F, Setter, MJ & Waterhouse, BM 2017, '*Limnobium laevigatum* (Amazonian frogbit) ecology and control in the Wet Tropics', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Setter, SD, Patane, KA, Madigan, BA & Setter, MJ 2011, 'Bogmoss (*Mayaca fluviatilis* Aubl.)—investigating control options for this new threat to our waterways', *Proceedings of the 11th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

18. Water weed management research

Project dates

October 2010 – June 2020

Project team

Tobias Bickel, Christine Perrett, Joseph Vitelli, Junfeng Xu (The University of Queensland) and Nguyen Nguyen (The University of Queensland)

Project summary

There are few efficient control options for managing aquatic weeds in Australia. This project develops efficient application techniques for the new herbicide flumioxazin in various situations and determines best management practice for integrated aquatic weed management.

We experimentally established minimum contact times to achieve cabomba and sagittaria control with flumioxazin. At 200 ppb ai (parts per billion active ingredient) subsurface application, excellent cabomba control was achieved in very short time periods. There was a 78% biomass reduction at 15 minutes and a 90% reduction at 1 hour. This suggests there is the possibility of controlling cabomba even in slow-flowing water. However, a contact time of 24 hours was necessary to achieve 90% control efficacy for sagittaria.

In collaboration with the Department of Environment and Science, we developed methods to determine flumioxazin concentration at trace levels in water, plant and soil samples. Detailed plans for large-scale field trials were drawn up to assess the efficacy, non-target damage, breakdown, uptake and retention of flumioxazin when applied to dense stands of cabomba in a large reservoir.

Flumioxazin is a new tool for efficient and economic control of established and emergent aquatic weeds in Queensland. In particular, for the first time, we will be able to manage cabomba on larger spatial and temporal scales. Future research will further improve application methods and examine the fate and breakdown of flumioxazin in the environment.

Assessing plant damage during an experiment on herbicide contact time

Collaborators

- CSIRO
- Queensland Department of Environment and Science
- Seqwater
- The University of Queensland
- Sumitomo Chemical
- NIWA
- Brisbane City Council
- Noosa and District Landcare
- Department of Economic Development, Jobs, Transport and Resources (Victoria)
- New South Wales Department of Primary Industries
- University of Düsseldorf (Germany)
- Griffith University
- Macspred

Key publications

Bickel, TO, Perrett, C, Vitelli, J, Xu, J & Adkins, S 2018, 'Control of *Cabomba caroliniana* with flumioxazin: control efficacy and the effect of environmental factors', *15th international symposium of aquatic plants*, Queenstown, New Zealand.

Bickel, TO 2017, 'Processes and factors that affect regeneration and establishment of the invasive aquatic plant *Cabomba caroliniana*', *Hydrobiologia*, vol. 788(1), pp. 157–168.

Bickel, TO 2015, 'A boat hitchhiker's guide to survival: *Cabomba caroliniana* desiccation resistance and survival ability', *Hydrobiologia*, vol. 746, pp. 123–134.

19. Giant rat's tail grass management

Project dates

July 2017 – June 2022

Project team

Wayne Vogler and Kelsey Hosking

Project summary

There has been a significant amount of work done on the ecology and management of giant rat's tail grass since the mid-1990s. The findings of this research have been published in a management manual, which was last updated in 2007. However, there is still more to be learnt about the use of flupropanate, the effective use of fertiliser, the effect of fire on flupropanate and management in seasonally wet areas. Through this project, we aim to increase knowledge to improve the management of giant rat's tail grass in a range of situations including grazing, peri-urban areas and forestry.

The project focuses on concerns raised by collaborators Gladstone Regional Council and Economic Development Queensland, but the results should have broad application across most management situations. We are conducting small-scale plot and pot trials over a number of years to gain knowledge that can assist current management programs.

Spraying giant rat's tail grass with herbicide

Collaborators

- Economic Development Queensland, Department of State Development, Manufacturing, Infrastructure and Planning
- Biosecurity officers
- Gladstone Regional Council
- Landholders

20. Management and ecology of fireweed (*Senecio madagascariensis*)

Project dates

July 2017 – June 2020

Project team

Joseph Vitelli, Kusinara Wijayabandara, Steve Adkins and Shane Campbell

Project summary

Fireweed (*Senecio madagascariensis* Poir.) is a short-lived perennial (sometimes annual) plant native to South Africa and Madagascar. It was introduced to Australia over 90 years ago and spread throughout pastures along the coast of New South Wales and south-eastern Queensland. However, its distribution in Australia is now unclear due, at least in part, to its confusion with the native *S. lautus* complex.

S. madagascariensis is difficult to eradicate and has the potential to compete strongly with useful pasture species under a range of fertility conditions. Further, like many *Senecio* species, it produces pyrrolizidine alkaloids, which when ingested by livestock reduce growth and in severe cases cause mortality. Sheep and goats are reported to be less susceptible to poisoning from pyrrolizidine alkaloids than cattle and horses.

Through this 3-year collaborative doctorate project with The University of Queensland, we will investigate:

- the reproductive output of *S. madagascariensis* in the Queensland environment
- its impact on native and introduced pasture plants
- determinants of invasiveness (in addition to reproductive capacity)
- management effectiveness.

Fireweed in south-eastern Queensland

Collaborators

- Kusinara Wijayabandara (PhD candidate), Steve Adkins and Shane Campbell, School of Agriculture and Food Sciences, The University of Queensland
- Irene Mills and Bruce Mills (Beechmont)

21. Eradication progress and biology of tropical weed eradication targets

Project dates

July 2008 – June 2021

Project team

Simon Brooks, Kirsty Gough, Stephen Setter and Melissa Setter

Project summary

In this project, we concentrate on the key biological parameters influencing the field operations that are targeting tropical weeds for eradication. These parameters include seed-bank persistence, age to maturity and dispersal potential. We also assesses control measures for these weeds.

Our field trials investigating seed persistence of *Miconia calvescens*, *M. racemosa*, *M. nervosa* and *Mikania micrantha* (run over 4–7 years, depending on the species) found persistent seed banks for all species. Also, our glasshouse trial of *Limnocharis flava* seed persistence under varying periods of immersion in water over 6 years recorded reduced seed viability in the driest annual treatments. These results clearly indicate that management options are needed for seed-bank depletion.

We are collating data on the growth to maturity and reproductive seasonality of invasive melastomes to refine guidelines for identifying and preventing seed-producing plants and assessing survey accuracy. Specifically, we are investigating a 'threshold size' at which plants mature for each *Miconia* species. The field data is supplemented with glasshouse pot trials where seedlings are established at 3-monthly (seasonal) intervals and grown to flowering to determine if the proportion of mature plants increases with plant size above a threshold.

We also develop and report on indicators of progress towards eradication using field data from the control teams.

Collaborators

- National Tropical Weeds Eradication Program
- Biosecurity officers (North Region)

Key publications

Weber, JM & Brooks, SJ 2013. 'The biology of Australian weeds 62. *Limnocharis flava* (L.) Buchenau', *Plant Protection Quarterly*, vol. 28(4), pp. 101–13.

22. War on northern invasive weeds

Project dates

July 2018 – June 2018

Project team

Wayne Vogler and Kelsey Hosking

Project summary

This project aimed to provide improved and innovative on-ground control techniques for prickly acacia in western Queensland and easier access to weed management information for landholders.

Spray misting is an approved control technique for prickly acacia. However, a planned demonstration trial was abandoned because continuing drought conditions made plant conditions unsuitable for effective spray misting.

The heli-drop ('Weed Sniper') comparative trial showed that the cost of this herbicide application technique compares favourably with that of ground application via quad bikes at prickly acacia densities of 1–2 plants per hectare. Mortality assessments from tebuthiuron application by quad bike and heli-drop are yet to be completed, as ongoing drought conditions have led to slow tebuthiuron activity.

Collaborators

- Southern Gulf NRM
- Desert Channels Queensland
- Central and north-western Queensland local governments
- Central and north-western Queensland and Southern Gulf landholders
- Biosecurity officers

Key publications

Vogler, W & Carlos, E 2015, 'Using helicopters: taking prickly acacia control to the next level', *Proceedings of the 13th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Carlos, E & Vogler, W 2015, 'Using pod and seed features to indicate prickly acacia seed viability', *Proceedings of the 13th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

March, N, Vogler, W & Dhileepan, K 2017, 'Advancing prickly acacia management through the war on western weeds initiative', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

23. Herbicide application research

Project dates

July 2009 – June 2020

Project team

Shane Campbell, Dannielle Brazier, Wayne Vogler and Kelsey Hosking

Project summary

The objective of this project is to improve herbicide control options for priority weeds in the central, western and northern parts of the state.

Low-volume, high-concentration applications of herbicide (e.g. using splatter guns and backpacks) have been effective in controlling weeds in areas that are difficult to access. We are now testing this technique on prickly acacia, rubber vine, chinee apple and gamba grass.

During the year, we established a trial on gamba grass to determine the efficacy of glyphosate applied at seven different rates. For prickly acacia, previous research identified a promising herbicide (aminopyralid/fluroxypyr—Hotshot™) and we initiated a new trial to improve efficacy by identifying the optimum way to spray plants (i.e. the amount of herbicide based on the surface area of one or both sides of plants and spraying undertaken on one or both sides of plants). We began a trial to compare the efficacy of monthly applications (December to May) of two herbicides (metsulfuron-methyl—Brush-off® and triclopyr/picloram/aminopyralid—Grazon™ Extra) on rubber vine to determine if there are seasonal and environmental influences that may affect mortality. We also commenced a screening trial on chinee apple incorporating five herbicides applied at two rates. In addition, we established demonstration sites on both chinee apple and prickly acacia to compare different application techniques, such as using backpack equipment or larger units mounted on an all-terrain vehicle.

Night-blooming cereus (*Cereus uruguayanus*) is a cactus species that is becoming problematic in parts of southern and central Queensland. To provide control options, we established several trials (screening, soil residual and cut stump) in central Queensland, incorporating a range of herbicides and techniques. While the plant appears to take a long time to die for many of the applied treatments, assessments of several herbicides at 18–24 months have recorded high mortality from basal, cut stump, stem injection and foliar applications. However, ground applications of soil-applied herbicides have had lower mortality rates and more variable results.

Collaborators

- Northern Gulf Resource Management Group
- Desert Channels Queensland
- Central Highlands Regional Council
- Central Highlands Regional Resources Use Planning Cooperative
- Biosecurity officers
- The University of Queensland

Key publications

McKenzie, J, Brazier, D, Campbell, S, Vitelli, J, Anderson, A & Mayer, R 2014, 'Foliar herbicide control of sticky florestina (*Florestina tripteris* DC.)', *The Rangeland Journal*, vol. 36, pp. 259–265.

Campbell, SD & Brazier, DA 2016, 'Developing additional herbicide control options for rubber vine (*Cryptostegia grandiflora* R.BR.)', *Proceedings of the 20th Australasian weeds conference*, The Weeds Society of Western Australia, Perth, pp. 284–287.

24. Control packages for statewide weed eradication targets

Project dates

July 2008 – June 2019

Project team

Joseph Vitelli, Annerose Chamberlain, Natasha Riding and Anna Williams

Project summary

This project aims to develop reliable and effective control options that can be integrated into eradication programs for priority weeds in Queensland.

Through an integrated control study in a sugarcane-growing area near Mackay, we are investigating the efficacy of agronomic practices for depleting the red witchweed seed bank and preventing further seed production over a 10-year period. Pre- and post-emergent herbicides are applied to sugarcane and are being compared with catch crops, trap crops and fumigants. We established a new trial to determine whether seed depletion of red witchweed can be accelerated with a continuous false host soybean crop, punctuated with multiple applications of the fumigant ethylene.

To evaluate eradication efforts on infested properties, we buried 300 perforated PVC canisters each containing three sachets of red witchweed (each sachet containing ~100 seeds) at depths of 100 mm, 300 mm and 500 mm across 25 sites covering the spectrum of treatments (soybean, ethylene and dazomet) that are currently being applied repeatedly or in combination on different topographies across the eight infested properties. We retrieved canisters after 24 and 36 months, and are continuing to assess seed viability.

Digitaria violascens, a widespread non-native grass species, has been confirmed as a new true host for red witchweed from glasshouse trials. During the eradication program, red witchweed has on occasions been recorded on the hinterland of infested sugarcane properties, along a fence line and on suspected grass hosts growing in among soybean. Previous attempts to confirm the grass host in the field have failed, as red witchweed readily detached from the host during transplanting. *Digitaria violascens* could provide red witchweed with a means to expand its distribution.

Ethylene remains critical to the success of the eradication program, but we need to learn more about this treatment. A new doctorate project aims to optimise ethylene application in the field.

Collaborators

- Local governments
- Biosecurity Queensland officers (Peter Austin, Dan Stampa and Michelle Smith)
- The University of Queensland

25. Native and introduced pathogens of giant rat's tail grass

Project dates

February 2017 – June 2020

Project team

Joseph Vitelli, Claire Lock, David Holdom, Annerose Chamberlain, Natasha Riding, Jimmy Hoskings, Roger Shivas, Diana Leemon and Yu Pei Tan

Project summary

Sporobolus R.Br. is a genus of 186 accepted grass species and 12 unresolved species in tropical and subtropical areas of the world, including Africa, temperate Asia, tropical Asia, Australasia, North America and South America. In Australia, 18 species are endemic and a further 6 species are naturalised. In rangelands, *Sporobolus* species are not desirable pasture grasses and usually indicate a degraded grazing system. The few native species regarded as favourable fodder species (*S. actinocladus*, *S. caroli*, *S. mitchellii* and *S. virginicus*), due to their high protein content when fresh, do not provide much bulk. The introduced weedy *Sporobolus* grasses are a serious concern to the grazing industry of eastern Australia. They cost the industry an estimated $60 million per annum and have the potential to completely dominate pastures at the exclusion of most other species. These weeds are referred to as the *S. indicus* complex, which includes *S. pyramidalis* and *S. natalensis* (giant rat's tail grass), *S. fertilis* (giant Parramatta grass), *S. africanus* (Parramatta grass) and *S. jacquemontii* (American rat's tail grass).

This project has two components:

- use of molecular tools to better target weedy *Sporobolus* with classical biocontrol agents and to study the genetic diversity of *Sporobolus*
- further investigations into endemic Australian pathogens of *Sporobolus*.

The *Sporobolus* leaf smut, *Ustilago sporoboli-indici*, was found in Queensland (first detection in Australia) on *S. natalensis* and is having a significant impact. Infected plants are stunted and void of inflorescences, and can be easily pulled out of the ground. The leaf smut has been found on over 30 properties around Taunton, Gin Gin, Conondale and Bundaberg. Wind appears to be the main dispersal mechanism. To date, the leaf smut has not been found on introduced or native pasture grasses growing near infected giant rat's tail grass.

In a glasshouse trial at the Ecosciences Precinct, we are investigating seed production and viability of giant rat's tail grass that is infected with the leaf smut. When the leaf smut was present at an early stage of inflorescence growth and at high infection levels, inflorescence length was ~3.5 cm and production was less than 1 seed per seed head. When the leaf smut was introduced during the later stages of inflorescence development, inflorescences failed to elongate and remained within the 'stem'. Inflorescence length was ~13.8 cm with seed production less than 12 seeds per inflorescence. Plants with very low levels of leaf smut infection had 'normal looking' inflorescences with lengths ~56 cm and producing ~900 seeds. Seed production of uninfected plants is ~1000 seeds per inflorescence.

We have so far purified 30 pathogen isolates (belonging to 13 genera) and sequenced their DNA to allow identification to genus level. These pathogens have been collected from infested plants found during field surveys. Several of them have genera (such as *Stagonospora*, *Microdochium*, *Colletotrichum* and *Pestalotiopsis*) that are recorded as effective grass pathogens overseas. We have spent a considerable amount of time identifying media that promote rapid growth and sporulation of the isolates. Media tested include potato dextrose agar, potato dextrose agar with Tween™, Sabouraud dextrose agar, oatmeal, V8™ juice agar and giant rat's tail extract. However, not all isolates are sporulating in the artificial media provided.

Also, we commenced a study testing Koch's postulates for the *Microdochium* isolate.

Collaborators

- AgriFutures Australia
- New South Wales Department of Primary Industries
- Department of Economic Development, Jobs, Transport and Resources (Victoria)
- New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce, via Rous County Council
- Bundaberg Regional Council (including Eric Dyke and James Anderson)
- Gladstone Regional Council (including Brett Cawthray, Glenn Cox, Melissa Hele and Rob Teakle)
- HQPlantations
- Trevor Dawson and Margaret Dawson (Taunton)

26. Influence of soil type on flupropanate availability for managing giant rat's tail grass

Project dates

February 2017 – June 2020

Project team

Joseph Vitelli, Rose Campbell, Jimmy Hoskings and Anna Williams

Project summary

The herbicide flupropanate (developed in the 1960s) is reported to have a long-lasting residual activity but is prone to movement within the soil horizons. Its selective residual activity (limiting the growth of emerging tussock grass seedlings), knockdown ability and availability (in both liquid and granular form) has made it the preferred herbicide for tussock weed management. Unfortunately, land managers are experiencing inconsistent levels of control and in some situations spending over $50 000 without killing any plants.

To investigate this, we have commenced two trials. The first focuses on the use of flupropanate and its effectiveness on a range of soils. The second will determine the flupropanate concentration required to effectively control or suppress tussock seedling emergence and the concentrations at which flupropanate begins to have adverse effects on competitive pasture emergents.

We established a pot trial involving three soil types (chromosol, ferrosol and kurosol) and two application methods (liquid and granular) to determine the residual behaviour of flupropanate. We also undertook an in-vitro dose response method to determine the susceptibility of 5 *Sporobolus* species and 5 competitive pasture species to 10 different flupropanate concentrations. Irrespective of herbicide treatment, 60% of flupropanate applied was lost within 6 months of application. Soil type had little effect on the behaviour of the herbicide; however, granular flupropanate persisted longer than liquid flupropanate. *S. creber* and *Chloris gayana* (Rhodes grass) were significantly affected at flupropanate concentrations lower than the recommended rate of active ingredient (1.5 kg/ha). *S. natalensis* and *S. africanus* were affected only by rates three times higher than the recommended rate.

Collaborators

- Powerlink Queensland
- School of Earth and Environmental Sciences, The University of Queensland
- Peter Thompson, Elgin (Conondale)
- Larry Cooper, Redlands Research & QCDF Facility
- Judith Ruhle, Jalbirri (Bongeen)
- Errol Stenzel, Bunburra (Boonah)

27. Land management, soil chemistry and control of giant rat's tail grass using flupropanate

Project dates

December 2016 – June 2019

Project team

Joseph Vitelli, Annerose Chamberlain, Natasha Riding, Anna Williams and Rose Campbell

Project summary

Current control efforts for weedy *Sporobolus* grasses centre on the use of chemical, mechanical, plant-competition and pasture-management methods. Despite the production of a best practice manual for weedy *Sporobolus* grasses and the widespread use of these control strategies, successful control has been difficult to achieve and weedy *Sporobolus* grasses continue to rapidly spread into new areas. Of the available herbicides, flupropanate is preferred because of its knockdown ability, residual activity and availability (both liquid and granular form). However, many landholders are experiencing poor control of giant rat's tail grass when using flupropanate

Maximising flupropanate levels in the soil will lead to more effective control and longer suppression of seedling recruitment. To address inconsistencies in control of giant rat's tail grass, we have monitored flupropanate levels in both soil and pasture. Our findings will help land managers with the timing of follow-up control. A trial at Conondale is investigating whether the amount of flupropanate reaching the soil is influenced by paddocks being burnt, heavily grazed or lightly grazed before herbicide application. The trial is also assessing how flupropanate availability is influenced by soil type, fertility and moisture, and application rate.

We treated each of 132 plots with one of the following: liquid flupropanate, granular flupropanate, an experimental product from Granular Products or glyphosate. In addition, we applied either an organic or an inorganic fertiliser. The data collected included flupropanate residue levels in plants and soil over a 12-month period, pasture yield, plot weediness and seed head production of giant rat's tail grass over time. The trial is now complete, and residue levels have only recently been analysed.

Collaborators

- Eliza Barrett and John McKenzie, Granular Products Pty Ltd
- AusIndustry Grants, federal Department of Innovation, Industry, Science and Research
- Peter Thompson, Elgin (Conondale)
- Stephen Were, Chemical Residue Laboratory, Biosecurity Queensland

28. Improved decision-support tools for weed eradication

Project dates

July 2016 – December 2018

Project team

Joe Scanlan, Steve Csurhes, Moya Calvert and Peter Austin

Project summary

A review of the 49 weeds targeted for eradication in Queensland divided them into eradicated, on track for eradication, uncertain and non-eradicable. About 40% fell into the 'uncertain' category. We need a systematic approach to determine objectively how these weeds can best be managed. Also, eradication programs for individual weeds need analytical and modelling support, including assessment of progress towards eradication. This information will influence decisions about which Queensland weeds should be prioritised for eradication.

A preliminary assessment of our current databases (Pest Central and BORIS) indicates that they give a good picture of current distribution and abundance of the major weed species. However, the data available is not sufficient to allow straightforward modelling of progress towards eradication of weeds. The main problems are:

1. Search effort across years varies but is not always recorded.
2. There are inconsistent recordings of 'nil detected' for previous occurrences.
3. Some cases record individual plants but others record large infestations with perimeters.
4. Not all known infestations are visited or treated in each year.

Data on red witchweed has been collected in a way that is amenable to modelling, and two different approaches to this have been developed. The first supports surveillance by predicting 4–8 weeks ahead the likely field occurrence of red witchweed above the ground. The second is an analysis of the reduction in field observation of the weed over the life of the eradication effort.

Key publications

Csurhes, S 2017, *Emerging weed threats detected in Queensland: risk assessment and prioritisation of 227 species*, Department of Agriculture and Fisheries, Brisbane.

Holden, MH, Nyrop, JP & Ellner, SP 2016, 'The economic benefit of time-varying surveillance effort for invasive species management', *Journal of Applied Ecology*, ‹https://doi: 10.1111/1365-2664.12617›.

Moore, JL, Runge, MC, Webber, BL & Wilson, JR 2011, 'Contain or eradicate? Optimizing the management goal for Australian acacia invasions in the face of uncertainty', *Diversity and Distributions*, vol. 17(5), pp. 1047–1059.

29. Regional pest prioritisation for research and management

Project dates

June 2016 – June 2018

Project team

Olusegun Osunkoya, Shane Campbell, Tony Pople, Moya Calvert, Brad Gray, Christine Perrett, Jason Callander and Biosecurity Queensland operation officers across the state

Project summary

We have developed a risk-based prioritisation of Queensland's established invasive plants and animals, using current species distribution, abundance and impacts. Our assessment followed collection of a comprehensive data set that included local government pest management plans, herbarium records, published literature and expert knowledge shared during a series of regional stakeholder workshops held over 2016–17 across the state.

Data analyses for the pest plants have been completed, while those for pest animals are ongoing. From ~300 invasive plant species that were identified as established in the state, only one-third (103) were considered by expert practitioners to pose significant risks across regions and therefore be management priorities. Stakeholders identified research and management activities for these species, including (in decreasing order) biocontrol, public education, herbicide use, ecology, taxonomy and risk analysis. Regions on the mainland eastern seaboard of the state share similar invasive species, so these regions may form a single management unit. Regions in the west and the extreme far north share fewer alien species, so are likely to need separate management.

In February 2018, another stakeholder workshop examined the cost-effectiveness and feasibility of management of the first 64 of the 103 priority weed species at the statewide level. These species are also listed as restricted or prohibited invasive plants in the Queensland *Biosecurity Act 2014*. In the workshop, for each invasive species, the main forms of weed management (biocontrol, chemical control and mechanical control, including the use of fire and integrated control) were discussed and rated in terms of effectiveness, practicality and cost. We are combining these ratings with the species priority rankings to generate a decision-support matrix. The matrix will identify preferred management, policy and research options for each species. A similar management workshop is planned for pest animals.

Collaborators

- Kristy Gooding, Local Government Association of Queensland
- Local government pest managers
- Local government executives and/or elected representatives
- Jens Froese and Sam Nicol, CSIRO
- Queensland Herbarium
- AgForce Queensland

Key publications

Booy, O, Mill, AC, Roy, HE, Hiley, A, Moore, N, Robertson, P, Baker, S, Brazier, M, Bue, M & Bullock, R 2017, 'Risk management to prioritise the eradication of new and emerging invasive non-native species', *Biological Invasions*, vol. 19, pp. 2401–2417.

Morin, L, Heard, T, Scott, J, Sheppard, A, Dhileepan, K, Osunkoya, O & van Klinken, R 2013, *Prioritisation of weed species relevant to Australian livestock industries for biological control*, Meat & Livestock Australia Limited, Sydney.

Part 2: Pest animal management

30. Rabbits in northern Queensland

Project dates

July 2013 – December 2018

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Rabbits have traditionally been in low numbers in northern Queensland, most likely due to the problems of breeding in this warmer part of the state. In 2012, reports from landholders and local governments suggested that numbers had increased. Monitoring of abundance and a better understanding of the biology of rabbits in northern Queensland was needed to determine if and how they are increasing in number.

In northern Queensland, temperatures are generally higher than what is considered tolerable for successful breeding (Cooke 1977). However, rabbits are persisting in this region and so must be successfully breeding. Surveys have shown that rabbits are using hollow logs and bushes as harbour (rather than constructing warrens) and have very small home ranges. Survival is generally low, with most rabbits not surviving past the first year; this may be due to exposure to predation as a result of not having warrens. Breeding is attempted year-round but with reduced litter sizes. There is no attempt to produce successive litters, which could be because females need to regain body condition before attempting to breed again. Rabbit numbers appear to have increased following a number of years with higher than average rainfall, but during the study period numbers have steadily declined with consecutive years of lower rainfall.

Collaborators

- Tablelands Regional Council
- Mareeba Shire Council
- Charters Towers Regional Council
- Dalrymple Landcare

Key publications

Cooke, B 1977, 'Factors limiting the distribution of the wild rabbit in Australia', *Proceedings of the Ecological Society of Australia*, vol. 10, pp. 113–120.

Cooke, BD, Brennan, M & Elsworth, P 2018, 'Ability of wild rabbit, *Oryctolagus cuniculus*, to lactate successfully in hot environments explains continued spread in Australia's monsoonal north', *Wildlife Research*, ‹https://doi/org/10.1071/WR17177›.

31. Monitoring the efficacy of new rabbit biocontrol

Project dates

April 2014 – June 2018

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Biocontrol agents have been essential to the effective management of rabbits across Australia. The effectiveness of myxomatosis and rabbit haemorrhagic disease virus (RHDV) have waned over time and vary regionally. The search for new agents resulted in an additional strain of rabbit calicivirus (RHDV1-K5) being released across Australia in March 2017 to provide another control method for rabbits. The impact of RHDV1-K5 varied from having little to no effect to up to 100% reduction in rabbit numbers. One valuable outcome of this release was the increase in awareness of rabbit issues and the need for ongoing management rather than a 'one-off' release.

A community warren-ripping program in Wallangarra (with support from the Queensland Murray–Darling Committee and Southern Downs Regional Council) has shown the effectiveness of mechanical control following a virus release. Monitoring of properties at Wallangarra showed a 15% decline in rabbit numbers following the release of RHDV1-K5 and a further 80% decline following warren ripping. The rabbit population has not increased in the 12 months since the warren ripping.

Ongoing monitoring will increase our understanding of the interactions between all the rabbit biocontrol viruses (RHDV1-351, RHDV1-K5, RHDVa, RHDV2, RCV-A1 and myxomatosis) as well as the effectiveness of harbour removal and destruction of key breeding areas.

Collaborators

- Centre for Invasive Species Solutions
- CSIRO
- New South Wales Department of Primary Industries
- South Australia Biosecurity
- Queensland Murray–Darling Committee
- Darling Downs – Moreton Rabbit Board
- Southern Downs Regional Council
- Toowoomba Regional Council

Key publications

Elsworth, PG, Kovaliski, J & Cooke, BD 2012, 'Rabbit haemorrhagic disease: are Australian rabbits (*Oryctolagus cuniculus*) evolving resistance to infection with Czech CAPM 351 RHDV?', *Epidemiology and Infection*, vol. 140, pp. 1972–1981.

Strive, T, Wright, JD & Robinson, AJ 2009, 'Identification and partial characterisation of a new lagovirus in Australian wild rabbits', *Virology*, vol. 384, pp. 97–105.

Strive, T, Elsworth, PG, Liu, J, Wright, JD, Kovaliski, J & Capucci, L 2013, 'The non-pathogenic Australian rabbit calicivirus RCV-A1 provides temporal and partial cross protection to lethal rabbit haemorrhagic disease virus infection which is not dependent on antibody titres', *Veterinary Research*, vol. 44, p. 51.

32. Assessing impact of rabbits on horticulture

Project dates

July 2013 – June 2018

Project member

Peter Elsworth

Project summary

Queensland produces one-third of Australia's fruit and vegetables, and these are valued at about $2 billion per year (Growcom). The Lockyer Valley region of south-eastern Queensland is a key area for vegetable growing and has recently begun to see impacts from rabbits.

Pen trials have shown that damage caused by rabbits is most significant at the seedling stage, when the entire plant is destroyed. After this stage, crop damage becomes superficial and there is no reduction in yield. Field trials show that even low to medium densities of rabbits can cause significant economic loss (>$100 000) in a very short time. Damage is most significant in the 15 m of crops closest to the rabbit harbour.

If rabbit pressure on crops is removed, the plants can recover and provide a full yield, but with a production delay equal to the amount of time rabbits were impacting the crop. Temporary electric fencing can provide short-term relief from rabbit damage, but long-term control is best achieved through harbour destruction. In the Lockyer Valley, rabbits primarily inhabit creek banks and sheds. Fire can be used to expose burrows along creek lines so they can be destroyed. Sheds can be fenced so the rabbits can be contained and trapped.

Collaborators

- The University of Queensland (Gatton)
- Darling Downs – Moreton Rabbit Board
- Lockyer Valley Regional Council
- Rugby Farms Pty Ltd
- Qualipac Pty Ltd

Key publications

Gong, W, Sinden, J, Braysher, M & Jones, R 2009, *The economic impacts of vertebrate pests in Australia*, Invasive Animals Cooperative Research Centre, Canberra.

33. Management of peri-urban deer in south-eastern Queensland

Project dates

July 2017 – June 2020

Project team

Michael Brennan, Matt Amos, Tony Pople, Hellen Haapakoski and Stacy Harris

Project summary

Wild deer abundance and distribution appear to be increasing across Australia, including in the peri-urban environment. The increased interaction between growing deer and human populations in the peri-urban region is of particular concern. Deer present a serious road hazard, and fatalities from deer collisions are being increasingly recorded in eastern Australia. There are also other impacts, including loss of pasture and crops, potential disease transmission to domestic livestock, habitat modification, soil erosion, competition with native fauna and illegal hunting. However, control tools are limited to trapping, shooting and fencing. The efficacy of these is not known, and some methods are untenable in built-up areas.

Best-practice guidelines for controlling wild deer, together with on-ground training and supporting technical expertise, were identified as key needs at the 2016 national wild deer management workshop. This project forms part of a larger project with interstate collaborators on deer management through the Centre for Invasive Species Solutions. We aim to evaluate control operations, investigate alternative management tools and strategies, refine monitoring techniques, determine seasonal movements of deer and improve community engagement.

Collaborators

- Darren Sheil, Moreton Bay Regional Council
- Anthony Cathcart and Mark Kimber, Sunshine Coast Regional Council
- Ken English and Phil Herrington, Noosa Shire Council
- Ben Curley, Gympie Regional Council
- Rob Hunt, National Parks and Wildlife Service (New South Wales)
- Troy Crittle, Biosecurity, New South Wales Department of Primary Industries
- Biosecurity officers Duncan Swan, Matt Ryan and Lyn Willsher (Queensland)
- Biosecurity Queensland policy staff Petra Skoien and Carmel Kerwick
- Mark Ridge, Darling Downs – Moreton Rabbit Board

Key publications

Amos, M, Baxter, G, Finch, N, Lisle, A & Murray, P 2014, 'I just want to count them! Considerations when choosing a deer population monitoring method', *Wildlife Biology*, vol. 20(6), pp. 362–370.

Doerr, ML, McAninch, JB & Wiggers, EP 2001, 'Comparison of 4 methods to reduce white-tailed deer abundance in an urban community', *Wildlife Society Bulletin*, vol. 29(4), pp. 1105–1113.

Forsyth, D, Pople, T, Page, B, Moriarty, A, Ramsey, D, Parkes, J, Wiebkin, A & Lane, C (eds) 2017, *2016 national wild deer management workshop proceedings*, Invasive Animals Cooperative Research Centre, Canberra.

34. Ecology and management of chital deer in northern Queensland

Project dates

July 2014 – June 2022

Project team

Tony Pople, Mike Brennan and Matt Amos

Project summary

This project studies aspects of the ecology and management of chital deer (*Axis axis*), which were established in northern Queensland in the late 1800s. Unlike many other invasive vertebrate species, their spread has been relatively slow. However, in the last 20 years, landholders have reported an increase in chital deer abundance and an expansion of their range to a point where they were considered major pests. To develop long-term management strategies, we need information on control methods and the impacts, capacity for increase and spread of the deer. Limiting factors are likely to be a combination of dingo predation and food supply, particularly availability of water and high-quality food.

Chital life history from captive and field data shows maturity at 10 months, with single young born and about 1.6 young produced per year. This suggests a modest maximum rate of increase of around 160%. However, it must be balanced with the dramatic declines of ~70% from starvation recorded during drought over 2014–15. Populations are recovering, but aerial culling has maintained low densities on a number of properties. The diet of the deer is flexible, reflecting availability, and ranging from 56% grass in the dry season to 94% grass in the wet season.

The vast majority of deer occur within 5 km of homesteads, often at high density. Their location is influenced by food quality, predation risk and water availability. We are using satellite telemetry of adults and remote cameras to investigate habitat use of deer and wild dogs, while radio telemetry of fawns helps us to estimate their survival rates and identify causes of mortality. We have determined the availability of essential minerals in areas of high and low chital abundance.

The concentration of deer combined with drought-reduced densities provides an opportunity for cost-effective control. The life history suggests this should be feasible, but coordination among properties will be required to gain landscape control.

Collaborators

- Keith Staines and Glen Harry, Sporting Shooters Association of Australia
- Kurt Watter, masters student, The University of Queensland
- Dave Forsyth, New South Wales Department of Primary Industries
- Luke Woodford, Arthur Rylah Institute (Victoria)
- Jordan Hampton, Ecotone Wildlife Veterinary Services
- Nathan Morgan, Rodney Stevenson and Carl Anderson, Biosecurity Queensland
- Ashley Blokland, Charters Towers Regional Council
- Helene Aubault, Dalrymple Landcare
- Rachael Payne, NQ Dry Tropics
- Catherine Kelly, Ben Hirsch, Lin Schwarzkopf and Iain Gordon, James Cook University

Key publications

Forsyth, D, Pople, T, Page, B, Moriarty, A, Ramsey, D, Parkes, J, Wiebkin, A & Lane, C (eds) 2017, *2016 national wild deer management workshop proceedings*, Invasive Animals Cooperative Research Centre, Canberra.

Forsyth, DM, Ramsey, DSL, Veltman, CJ, Allen, RB, Allen, WJ, Barker, RJ, Jacobson, CL, Nicol, SJ, Richardson, SJ & Todd, CR 2013, 'When deer must die: large uncertainty surrounds changes in deer abundance achieved by helicopter- and ground-based hunting in New Zealand forests', *Wildlife Research*, vol. 40, pp. 447–458.

Kilgo, JC, Ray, HS, Vukovich, M, Goode, MJ & Ruth, C 2012, 'Predation by coyotes on white-tailed deer neonates in South Carolina', *The Journal of Wildlife Management*, vol. 76, pp. 1420–1430, ‹https://doi: 10.1002/jwmg.393›.

35. Predation of chital deer and cattle by wild dogs in northern Queensland

Project dates

July 2016 – December 2018

Project member

Lee Allen

Project summary

Chital deer were introduced to Maryvale Station north of Charters Towers in the 1880s, but until recently have not been a concern to producers. They are now found over many stations in the region.

Preliminary investigations into the prey remains detected in wild dog scats collected within the chital distribution suggest wild dogs may play a strong role in controlling deer by preying on fawns. To confirm this, we collected scat samples in September and November 2017, and in February and May 2018. While deer remains were significant, the frequency of occurrence of deer has declined recently and the proportion of unidentifiable debris in scats has increased. This appears to reflect poor seasonal conditions and a general decline in populations of deer and other prey.

Wild dog predation and management may significantly affect the local and regional distribution and abundance of deer. However, while wild dogs may have a beneficial role in controlling deer, they are also known predators of beef cattle. To date, few scats have been found to contain cattle remains, and many of those that did also contained maggots, indicating that the cattle remains had been scavenged.

We will continue to monitor the diet of wild dogs in this key northern Australia location to determine whether there is seasonal switching between prey species.

Collaborators

- Tony Pople, Michael Brennan and Jarud Muller

Key publications

Allen, L, Goullet, M & Palmer, R 2012, 'The diet of the dingo (*Canis lupus dingo* and hybrids) in north-eastern Australia: a supplement to the paper of Brook and Kutt (2011)', *The Rangeland Journal*, vol. 34, pp. 211–217.

Allen, LR 2014, 'Wild dog control impacts on calf wastage in extensive beef cattle enterprises', *Animal Production Science*, vol. 54(2), p. 214.

Allen, L 2017, 'Is landscape-scale wild dog control the best practice?' *Australasian Journal of Environmental Management*, vol. 24(1), pp. 5–15.

36. Cluster fencing evaluation

Project dates

October 2013 – December 2018

Project team

Lee Allen, Peter Elsworth, Joe Scanlan and Tony Pople

Project summary

In 2013, South-West Natural Resource Management contracted graziers to erect several 'cluster fences' around multiple properties to allow the elimination of wild dogs and the control of kangaroo and other pest populations inside the fenced area. This strategy offers some hope for Queensland's sheep industry, which is seriously affected by the dual impacts of predation by wild dogs and overgrazing by kangaroos and introduced pests.

This project monitors the abundance of kangaroos, wild dogs and other wildlife, as well as pasture biomass and condition, before and after the erection of cluster fences. The findings will provide empirical information to evaluate the cluster fencing strategy. Our monitoring compares pest abundance and pasture condition on individual properties within the Morven and Tambo clusters (the first two cluster fences completed in Queensland) with those of properties outside.

There are several direct and indirect economic and social benefits of cluster fencing. However, ultimately the success of cluster fencing will be determined by the extent to which livestock production in the cluster improves relative to livestock production in comparable areas outside the cluster, less the cost of establishing and maintaining the cluster fence and reduced pest populations.

There is a wide range of pasture/land types within the Morven and Tambo clusters and in neighbouring areas. We have inspected established pasture monitoring sites at Morven three times in 2017–18, and 42 monitoring sites have now been established within and around the Tambo cluster. Both within and outside the Morven cluster, pasture condition has varied over time, with no consistent trends evident at this stage. With continued dry seasonal conditions, patchy rainfall distribution and mobile pest populations, it will take many years before any consistent differences between inside and outside the cluster will be detectable. Extension to and subdivision of cluster fences has further complicated monitoring and data analysis.

Results from monitoring wildlife activity have been mixed. Inside the Morven cluster fence, the erection of subdivisional fences and the employment of a contract trapper have led to over 500 wild dogs being removed; wild dogs are now scarce inside the cluster. In contrast, kangaroos inside the cluster had been increasing relative to those outside the cluster over the initial post-construction years, but poor seasonal conditions during 2017–18 led to a substantial decline in kangaroos regionally. Although only 200 km away, the Tambo district had excellent summer rain in early 2018, but there too, earlier dry conditions were linked to declines in kangaroo abundance regionally. Monitoring continues to indicate there is little difference between dog activity inside and that outside the Tambo cluster fence.

Collaborators

- Emma Turner, South West NRM
- Bill Johnson, Department of Agriculture and Fisheries
- Philip Maher, Department of Natural Resources, Mines and Energy

37. Anti-predator behaviour in livestock

Project dates

July 2017 – July 2019

Project member

Lee Allen

Project summary

Experienced adult cattle generally repel wild dog attacks, but deaths of or bites to calves and weaners can be a significant source of economic loss to farmers. In northern Australia, most calf loss occurs within 10–14 days of birth and 40–50% of deaths are attributed to unknown causes.

A recent CashCow study (funded by Meat and Livestock Australia) recorded a mean 5% greater calf loss on properties whose owners believed wild dogs to be a problem. There is ~10% greater calf loss from first-calf cows than from mature cows, and substantially greater calf loss in northern Queensland than in southern and south-western Queensland. However, there is no difference in calf loss between properties that had been baited several times per year and those that had been baited annually or not at all.

The CashCow study has prompted further research into calf loss, husbandry practices and how management interventions might reduce losses from wild dogs. In this project, we will use a remote-controlled model dog to:

- examine how anti-predator defences develop in calves, weaners and first-calf mothers
- determine whether defence behaviours can be learned from experienced associates
- determine whether experienced 'coacher cows', when pastured with younger cattle, train and/or protect these younger animals from wild dog attacks.

The model dog that will be placed on a robotic platform to elicit anti-predator behaviour in cattle

Collaborators

- Ben Hirsch and Wayne Morris, James Cook University

38. Peri-urban wild dogs

Project dates

April 2018 – June 2022

Project team

Matthew Gentle, Lana Harriott and James Speed

Project summary

Small landholdings, varied land use, high human density and media exposure create distinct difficulties for the management of peri-urban pests. For wild dog management, recently released tools (e.g. PAPP bait, ejectors) have perceived benefits—such as humaneness, available antidote, target specificity and efficacy—that may improve the application of control techniques in peri-urban areas. However, these tools have restrictions similar to those for existing 1080 baiting—application is limited and landscape-scale implementation is precluded. Control objectives may need to focus more on specific individuals, groups or impacts, to ensure wild dogs responsible for impacts are targeted.

In this new project, we aim to develop and test management strategies for wild dogs in peri-urban areas. Increasingly, public opposition to culling programs has thwarted control efforts, so community engagement is needed to determine and guide appropriate management strategies. Behavioural science and engagement approaches will complement ecological research to successfully identify, implement and monitor the success of strategies for managing wild dogs in the landscape.

Collaborators

- New South Wales Department of Primary Industries
- Local Land Services (New South Wales)
- Griffith University
- Sunshine Coast Regional Council
- Brisbane City Council
- Landholders
- Centre for Invasive Species Solutions

39. Non-target impacts of 1080 pig baits

Project dates

June 2014 – June 2018

Project team

Peter Cremasco, Matthew Gentle and Joe Scanlan

Project summary

In this project, we examine two feral pig 1080 baiting practices—the application of meat baits in the absence of pre-feeding or bait stations, and the use of baits prepared from fruit and vegetable materials. Both practices have a long history of use in Queensland to protect agriculture and the environment. The Australian Pesticides and Veterinary Medicines Authority initially rejected the inclusion of these methods in the future registration of the Queensland 1080 concentrate, given the limited assessments available on their impacts on non-target species. However, they agreed to permit continued legacy use while studies are undertaken to collect and collate relevant data.

We undertook six field studies in areas of Queensland where baiting for feral pigs using various bait substrates containing 1080 is common:

- Ingham—banana and mango substrates in horticulture and canefields
- Gore—meat substrate in sheep production enterprises
- Moonie—meat substrate in conservation lands
- Greenvale—meat substrate in cattle enterprises
- Hebel and Hungerford—meat substrate in conservation and cattle production areas.

We collected data on baiting efficacy, the identity of non-target species visiting and consuming bait material, population counts of theoretically susceptible birds, and activity of varanids before and after baiting. We also monitored control sites to provide a comparison. The results analysed so far suggest there is little impact to populations of non-target species and high efficacy from fruit baiting.

Collaborators

- Hinchinbrook Shire Council
- Herbert Cane Productivity Services
- Queensland Parks and Wildlife Service
- Charters Towers Regional Council
- Landholders

Key publications

Cremasco, P, Gentle, M, Wilson, CJ, Di Bella, L & Buckman, M 2016, 'Feral pig baiting with fruit in the Wet Tropics', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 103–106.

Cremasco, P & Bacchiella, D 2017, 'A strategy for effectively managing feral pig impacts in agricultural enterprises in northern Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 141.

Millar, A, Gentle, M & Leung, L 2015, 'Non-target species interaction with sodium fluoroacetate (1080) bait for controlling feral pigs (*Sus scrofa*) in southern Queensland', *Pacific Conservation Biology*, vol. 21, pp. 58–162.

40. Accuracy of an unmanned aerial vehicle (drone) in estimating macropod abundance

Project dates

June 2014 – December 2019

Project team

Matthew Gentle, James Speed and Tony Pople

Project summary

Using an unmanned aerial system (UAS or drone) to recording thermal and colour imagery could be safer and cheaper than having human observers undertake aerial surveys of terrestrial wildlife. To trial this, we conducted drone flights in the Roma region, immediately following conventional aerial (helicopter) surveys undertaken by the Department of Environment and Science.

The drone was able to survey only ~56% of the 320 km of helicopter survey transects, given airspace restrictions and technical issues. Five species of macropod were recorded by observers during the helicopter surveys. The imagery recorded by the drone was of insufficient quality to differentiate between macropod species. Correspondingly, macropod density estimates from the drone survey data were relatively low (3.2 animals per square kilometre) compared to the conventional helicopter surveys (38.5 animals per square kilometre).

Recent advances in camera technology and methodological refinements are encouraging for the aerial survey of wildlife using drones. However, improvements in detection and identification technology are needed to match or exceed the accuracy of the conventional aerial survey technique for kangaroos.

Collaborators

- Neal Finch, Queensland Department of Environment and Science
- Ninox Robotics

41. Feral cat ecology and management

Project dates

June 2014 – December 2019

Project team

Matthew Gentle, Bronwyn Fancourt, James Speed, Cameron Wilson, Glen Harry and Christine Zirbel

Project summary

Feral cats threaten wildlife, agriculture and human health through predation, competition and the spread of infectious diseases such as toxoplasmosis. Management of feral cat populations using intensive control measures such as trapping, shooting and exclusion fencing can be effective but are expensive, time-consuming and generally unsuitable for broadscale use. The recent development of a new chipolata-style bait has shown some success in Western Australia and central Australia, but its non-target impacts and efficacy have not been tested in Queensland, and these are required for regulatory approval. In this project, we investigate a range of options for the broadscale control of feral cats in Queensland environs. Through collaboration, we are also investigating the effects of cat removal on prey species.

A new chipolata-style 1080 feral cat bait, Eradicat®, was aerially deployed at high bait densities (up to 50 baits per square kilometre) across Taunton National Park in central Queensland during July 2017. A combination of camera traps and cat-borne mortality collars indicated a 29–40% reduction in feral cat abundance following baiting. This was a marked improvement from the fresh meat baits used in 2016, which killed only 11% of collared cats and led to no detectable reduction in cat abundance across the site.

A feral cat investigating a fresh meat bait

We also assessed the potential impacts to bird species from the Eradicat baiting at Taunton. We compared the densities of a number of bird species before and after baiting using bird counts conducted at Taunton (baited) and at a control (unbaited) site. Total bird density appeared to increase following baiting at Taunton and decrease at the control site, but the differences were not statistically significant. It is likely that fluctuations in counts are due to bird movements in response to resource availability, rather than a baiting effect.

We are undertaking additional trials to assess the potential risk to non-target species from Eradicat baiting in other Queensland environs. During spring, 100 Eradicat baits were deployed at Culgoa Floodplain National Park in south-western Queensland. They were placed along tracks (to simulate ground baiting) and also off-track (to simulate aerial baiting). Remote cameras monitored each individual bait. In the first 3 days, 32% of the baits were removed; this increased to 55% by day 12. Goannas removed 19 of the 55 baits taken, and birds removed a further 5 baits. Cameras did not detect which species removed the remaining baits. Goannas are considered a low (insignificant) risk of mortality from consuming cat baits. However, they can reduce the availability of bait to cats. Baiting during cooler periods (i.e. winter), when goannas are less active, is recommended. Baiting during winter is also considered best-practice timing to improve uptake by feral cats.

We deployed 50 cameras across Moorrinya National Park in northern Queensland during autumn to investigate feral cat activity and assess any potential risk of Eradicat baits to Julia Creek dunnarts. The cameras recorded 34 cat interactions but none for Julia Creek dunnarts. The high cat abundance and observed low risk to (non-target) dunnarts suggests that Moorrinya could be a suitable site for a large-scale Eradicat baiting trial in 2019.

Reviewing images from monitoring cameras is time-consuming, especially because of the need to review excessive images resulting from false triggers. Collaborators Deves Falzon Pty Ltd have successfully developed algorithms to detect whether single images or image sequences contain 'objects of interest' (i.e. animals) rather than merely background movement. Further research is underway to develop an algorithm to detect cats in images. Collectively, these developments would greatly improve the efficiency of reviewing and processing camera images.

Collaborators

- Barry Nolan, Queensland Parks and Wildlife Service, Department of Environment and Science (Airlie Beach)
- John Augusteyn, Queensland Parks and Wildlife Service, Department of Environment and Science (Rockhampton)
- Jane Oakey and Craig Smith, Biosecurity Queensland (Coopers Plains)
- Jessica Guidotti and Diana Fisher, The University of Queensland
- Greg Falzon, Deves Falzon Pty Ltd
- Various private landholders

Key publications

Fancourt, B, Speed, J & Gentle, M 2016, 'Uptake of feral cat baits in eastern Australia', *Proceedings of the 5th Queensland pest animal symposium*, Townsville, pp. 99–102.

Fancourt, B, Speed, J & Gentle, M 2017, 'Do dingoes supress feral cats? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 119.

Wilson, C, Fancourt, B, Speed, J & Gentle, M 2017, 'Home range and habitat utilisation of feral cats (*Felis catus*) in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 99.

Part 3: Research services

42. Chemical registration—providing tools for invasive pest control

Project dates

July 2012 – June 2019

Project team

Joe Vitelli and David Holdom

Project summary

Biosecurity Queensland holds permits for the use of pesticides to control invasive plants and animals. The need for permits has increased as pesticide registrants focus primarily on more profitable crop protection rather than environmental protection, resulting in reduced availability for controlling invasive species outside of crops.

Twelve new permits were issued to Biosecurity Queensland during 2017–18 by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Eleven permits related to weeds (alligator weed, bellyache bush, cat's claw creeper, coral cactus, environmental weeds, hymenachne, parthenium and pimelia), and one permit was for the control of *Aconophora* found on fiddlewood. A further three permits for the control of lippia, witchweeds and thunbergia have been lodged with the APVMA.

Collaborators

- Local governments
- Seqwater
- Agribusiness, including Sumitomo Chemical, Nufarm Australia, Macspred and DowAgroSciences
- Department of National Parks, Recreation, Sport and Racing
- Department of Transport and Main Roads
- Biosecurity Queensland officers, including; Sonia Jordan, Steve Csurhes, Craig Hunter, Michael Graham, Lyn Willsher, John Reeves, Stacey Harris and Michelle Smith

Key publications

Twelve new permits were issued by the APVMA to Biosecurity Queensland during the 2017–18 financial year:

1. Permit (PER11540) Haloxyfop/Ponds, drainage areas, waterways, pastures, roads and utility reserves/ *Hymenachne*, expires 30 June 2020, ‹http://permits.apvma.gov.au/PER11540.PDF›.
2. Permit (PER13707) Metsulfuron methyl/Native pastures, rights of way, commercial and industrial areas/Bellyache bush, expires 30 September 2022, ‹http://permits.apvma.gov.au/PER13707.PDF›.
3. Permit (PER13406) Glyphosate/Terrestrial and aquatic areas in Queensland/*Hymenachne* spp., expires 30 June 2022, ‹http://permits.apvma.gov.au/PER13406.PDF›.
4. Permit (PER13549) Various herbicides/*Pimelea* spp./ Various situations, expires 30 November 2022, ‹http://permits.apvma.gov.au/PER13549.PDF›.
5. Permit (PER13812) Grazon and Access/Pastures, rights of way, commercial and industrial areas/Coral cactus, expires 30 November 2022, ‹http://permits.apvma.gov.au/PER13812.PDF›.
6. Permit (PER13706) Imidacloprid/Fiddlewood/*Aconophora compressa* Walker, expires 31 March 2023, ‹http://permits.apvma.gov.au/PER13706.PDF›.
7. Permit (PER10221) Metsulfuron-methyl 600 g/kg/ Non-potable waterways/Alligator weed, expires 31 December 2022, ‹http://permits.apvma.gov.au/PER10221.PDF›.
8. Permit (PER11463) Various products and chemicals/ Non-agricultural areas/Environmental weeds, expires 30 June 2023, ‹http://permits.apvma.gov.au/PER11463.PDF›.
9. Permit (PER81265) Haloxyfop/Aerial use/*Hymenachne*, expires 30 June 2023, ‹http://permits.apvma.gov.au/PER81265.PDF›.
10. Permit (PER10397) 2,4-D/Pastures and non-crop situations/*Bryophyllum pinnatum*, expires 30 June 2020, ‹http://permits.apvma.gov.au/PER10397.PDF›.
11. Permit (PER10367) Metsulfuron-methyl/Pastures and non-crop situations/Parthenium, expires 30 June 2023, ‹http://permits.apvma.gov.au/PER10367.PDF›.
12. Permit (PER10533) Glyphosate/Pasture, non-crop situations/*Macfadyena unguis-cati* (cat's claw creeper), expires 31 July 2028, ‹http://permits.apvma.gov.au/PER10533.PDF›.

43. Pest management chemistry

Project dates

Ongoing

Project team

Stephen Were, Patrick Seydel and Alyson Herbert

Project summary

This project provides chemistry services to science, policy and operational activities within Biosecurity Queensland's Invasive Plants and Animals program.

These services comprise pesticide advice and 1080 production for pest management in Queensland and toxicological and eco-toxicological investigations into the use of vertebrate pesticides. The project is undertaken in Biosecurity Queensland's Chemical Residue Laboratory at the Queensland Government's Health and Food Sciences Precinct at Coopers Plains, Brisbane.

Forensic toxicology

Over the year, our laboratory performed more than 75 investigations into possible animal poisonings—64 for sodium fluoroacetate, 14 for strychnine, 6 for anticoagulants and 1 for metaldehyde. While most investigations related to domestic dogs and cats, some involved livestock or macropods.

Formulation chemistry

During the year, our formulation facility produced 1115 L of 1080 (36 g/L) pig bait solution in accordance with upcoming registration of the formulation with the APVMA.

Testing of post-preparation sodium fluoroacetate solutions continued throughout the year.

External funding

Research and development contracts

Project/research area	Funding body	Funds ($)
Aquatic weed herbicide evaluation	Sumitomo Chemical	17 000
Biocontrol of cat's claw creeper	Seqwater	90 000
Biocontrol of bellyache bush	Meat and Livestock Australia	34 000
Biocontrol of parthenium	Meat and Livestock Australia	302 000
Biocontrol of parkinsonia	CSIRO	81 000
Biocontrol of *Cylindropuntia* cactus	New South Wales Department of Primary Industries	35 000
Biocontrol of mother-of-millions	New South Wales Department of Primary Industries	8 000
Biocontrol of prickly acacia	Australian Department of Agriculture and Water Resources and AgriFutures Australia	38 000
Biocontrol of giant rat's tail grass	Australian Department of Agriculture and Water Resources and AgriFutures Australia	58 000
Endemic pathogens of giant rat's tail grass	Australian Department of Agriculture and Water Resources and AgriFutures Australia	46 000
Giant rat's tail grass flupropanate control	Granular Products	47 000
Giant rat's tail grass flupropanate control	Australian Department of Industry, Innovation and Science (AusIndustry)	25 000
Giant rat's tail grass flupropanate control	Powerlink	26 000
Herbicide control of rangeland weeds	Australian Department of Agriculture and Water Resources	58 000
Biocontrol of giant rat's tail grass	Bundaberg Regional Council, Gladstone Regional Council, New South Wales Department of Primary Industries, New South Wales Environmental and Aquatic Weeds Biocontrol Taskforce	14 000
Wild dog and deer management	Centre for Invasive Species Solutions	15 000
TOTAL		**894 000**

Land Protection Fund

Project/research area	Funds ($)
Weed seed dynamics	25 000
Herbicide application research	52 000
Biocontrol of bellyache bush	204 000
Biocontrol of prickly acacia	203 000
Biocontrol of cat's claw creeper	73 000
Biocontrol of cactus	174 000
Biocontrol of lantana	43 000
Biocontrol of mother-of-millions	62 000
Biocontrol of parthenium	271 000
Biocontrol of giant rat's tail grass	56 000
Rearing and release of weed biocontrol agents	134 000
Water weed ecology and management	163 000
Wet Tropics best-practice research	14 000
Feral deer best-practice research	225 000
Wild dog best-practice research	111 000
Rabbit best-practice research	237 000
Non-target impacts of 1080 pig baits	130 000
Pesticide authorities	71 000
Pest management chemistry and chemical registration	84 000
TOTAL	**2 391 000**

Research staff

Ecosciences Precinct

GPO Box 267, BRISBANE QLD 4001
Tel: (07) 3255 4518 **Fax:** (07) 3846 6371
Email: donna.buckley@daf.qld.gov.au **Email for other staff:** firstname.lastname@daf.qld.gov.au

Dr Tony Pople	Principal scientist
Dr Kunjithapatham Dhileepan	Principal entomologist
Dr Olusegun Osunkoya	Senior scientist
Dr Tobias Bickel	Aquatic weed scientist
Joseph Vitelli	Principal weed scientist
Michael Day	Senior entomologist
Patrick Rogers	Senior operations supervisor
Di Taylor	Scientist
Michael Brennan	Experimentalist
Tamara Taylor	Experimentalist
Dr Lana Harriott	Project officer
David Holdom	Project officer
Natasha Riding	Experimentalist
Liz Snow	Experimentalist and quarantine manager
Annerose Chamberlain	Experimentalist
Peter Jones	Experimentalist
Christine Perrett	Experimentalist
Jason Callander	Project officer
Boyang Shi	Project officer
David Fredericks	Experimentalist
Anna Williams	Experimentalist
Dr Bill Palmer	Research fellow (emeritus)
Jimmy Hosking	Experimentalist
Jayd McCarthy	Experimentalist
Donna Buckley	Administration officer

Health and Food Sciences Precinct

PO Box 156, ARCHERFIELD QLD 4108
Tel: (07) 3276 6112 **Fax:** (07) 3216 6565 **Email:** alyson.herbert@daf.qld.gov.au

Alyson Herbert	Experimentalist

Pest Animal Research Centre

PO Box 102, TOOWOOMBA QLD 4350
Tel: 13 25 23 **Fax:** (07) 4688 1199 **Email for staff:** firstname.lastname@daf.qld.gov.au

Dr Joe Scanlan	Principal scientist
Dr Matthew Gentle	Senior zoologist
Dr Lee Allen	Senior zoologist (based in Townsville)
Dr Bronwyn Fancourt	Project officer
Dr Matt Amos	Project officer
Peter Cremasco	Project officer
Dr Peter Elsworth	Experimentalist
James Speed	Experimentalist
Christine Zirbel	Experimentalist
Glen Harry	Experimentalist (casual)

Tropical Weeds Research Centre, Charters Towers

PO Box 187, CHARTERS TOWERS QLD 4820
Tel: (07) 4761 5700 **Fax:** (07) 4761 5757
Email: Evelyn.Cady@daf.qld.gov.au **Email for other staff:** firstname.lastname@daf.qld.gov.au

Dr Shane Campbell	Professional leader
Dr Wayne Vogler	Senior weed scientist
Dr Faiz Bebawi	Research fellow (emeritus)
Simon Brooks	Weed scientist
Dannielle Brazier	Experimentalist
Barbara Madigan	Research fellow (emeritus)
Kelli Pukallus	Experimentalist
Rodney Stevenson	Operations supervisor
Carl Andersen	Maintenance officer
Kelsey Hosking	Experimentalist
Kirsty Gough	Scientific assistant
Judy Clark	Scientific assistant
Joshua Nicholls	Experimentalist
Evelyn Cady	Administration officer

Tropical Weeds Research Centre, South Johnstone

PO Box 20, SOUTH JOHNSTONE QLD 4859
Tel: (07) 4220 4177 **Fax:** (07) 4064 2249 **Email:** leanne.wright@daf.qld.gov.au **Email for other staff:** firstname.lastname@daf.qld.gov

Melissa Setter	Weed scientist
Stephen Setter	Experimentalist

Publications and presentations

Journal articles

Allen, L 2017, ‘Is landscape-scale wild dog control the best practice?’, *Australasian Journal of Environmental Management*, vol. 24(1), pp. 5–15.

Bebawi, FF, Campbell, SD & Mayer, RJ 2017, ‘Seed ecology of Captain Cook tree [*Cascabela thevetia* (L.) Lippold]—germination and longevity’, *The Rangeland Journal*, vol. 39(4), pp. 307–316.

Bebawi, FF, Campbell, SD, Mayer, RJ, Setter, MJ & Setter, SD 2018, ‘Effects of temperature and burial on seed germination and persistence of the restricted invasive *Stevia ovata* in northern Queensland’, *Australian Journal of Botany*, vol. 66, pp. 388–397.

Bickel, TO 2017, ‘Processes and factors that affect regeneration and establishment of the invasive aquatic plant *Cabomba caroliniana*’, *Hydrobiologia*, vol. 788(1), pp. 157–168.

Booy, O, Mill, AC, Roy, HE, Hiley, A, Moore, N, Robertson, P, Baker, S, Brazier, M, Bue, M & Bullock, R 2017, ‘Risk management to prioritise the eradication of new and emerging invasive non-native species’, *Biological Invasions*, vol. 19, pp. 2401–2417.

Canlas, CP, Gever, CML, Rosialda, PBR, Quibod, MNRM, Buenavente, PAC, Barbecho, NM, Layusa, CAA & Day, M 2017, ‘Assessment of the possible effects of biological control agents of *Lantana camara* and *Chromolaena odorata* in Davao City, Mindanao, Philippines’, *International Journal of Agricultural and Biosystems Engineering*, vol. 11(4), p. 1.

Cooke, BD, Brennan, M & Elsworth, P 2018, ‘Ability of wild rabbit, *Oryctolagus cuniculus*, to lactate successfully in hot environments explains continued spread in Australia’s monsoonal north’, *Wildlife Research*, ‹https://doi/org/10.1071/WR17177›.

Dhileepan, K, Neser, S, Rumiz, D, Raman, A & Sharma, A 2017, ‘Host associations of gall-inducing *Prodiplosis longifila* (Diptera: Cecidomyiidae) from Bolivia: implications for its use as a biological control agent for *Jatropha gossypiifolia* (Euphorbiaceae)’, *Florida Entomologist*, vol. 100, pp. 777–786.

Dhileepan, K, Shi, B, Callander, J, Teshome, M, Neser, S & Senaratne, KADW 2018, ‘Gall thrips *Acaciothrips ebneri* (Thysanoptera: Phlaeothripidae) from Ethiopia, a promising biological control agent for prickly acacia in Australia’, *African Entomology*, vol. 26, pp. 237–241.

Fancourt, BA, Sweaney, M & Fletcher, DB 2018, ‘More haste, less speed: pilot study suggests camera trap detection zone could be more important than trigger speed to maximise species detections’, *Australian Mammalogy*, vol. 40(1), pp. 118–121.

Hampton, JO, Finch, NA, Watter, K, Amos, M, Pople, T, Moriarty, A, Jacotine, A, Panther, D, McGhie, C, Davies, C, Mitchell, J & Forsyth, DM 2018, ‘A review of methods used to capture and restrain introduced wild deer in Australia’, *Australian Mammalogy*, ‹https://doi.org/10.1071/AM17047›.

Lavery, TH, Pople, AR & McCallum, HI 2018, ‘Going the distance on kangaroos and water: a review and test of artificial water point closures in Australia’, *Journal of Arid Environments*, vol. 151, pp. 31–40.

Macanawai, AR, Day, MD & Adkins, SW 2018, ‘Seed biology of mile-a-minute (*Mikania micrantha*) in Viti Levu, Fiji’, *Weed Research*, vol. 58, pp. 229–238.

Osunkoya, OO, Akinsanmi, OA, Lim, LSA, Perrett, C, Callander, J & Dhileepan, K 2017, ‘*Parthenium hysterophorous* L. (Asteraceae) had limited impact on major soil nutrients and enzyme activity: Is the null effect real or reflects data insensitivity?’, *Plant & Soil*, vol. 420, pp. 177–194.

Osunkoya, OO, Nicol, S, Perrett, C, Moore, K, Callander, J, Gooding, K & Campbell, S 2018, ‘A risk-based inventory of invasive plant species of Queensland, Australia: regional, ecological and floristic insights (2018)’, submitted to *Austral Ecology*.

Peacock, DE, Fancourt, BA, McDowell, MC & Abbott, I (in press), ‘Survival histories of marsupial carnivores on Australian continental shelf islands highlight climate change and Europeans as likely extirpation factors: implications for island predator restoration’, *Biodiversity and Conservation*, ‹https://doi.org/10.1007/s10531-018-1546-6›.

Shabbir, A, Bajwa, AA, Dhileepan, K, Zalucki, M, Khan, N & Adkins, S 2018, ‘Integrated use of biological approaches provide effective control of parthenium weed’, *Archives of Agronomy and Soil Science*, vol. 64.

Shen, S, Day, MD, Xu, G, Li, D, Jin, G, Yin, X, Yang, Y, Liu, S, Zhang, Q, Gao, R, Zhang, F & Winston, RL 2018, ‘The current status of biological control of weeds in southern China and future options’, *Acta Ecologica Sinica*, vol. 38, pp. 157–164.

Vitelli, JS, Tan, YP, Riding, N, Holdom, DG, Chamberlain, A & Shivas, RG 2017, ‘First record of *Ustilago sporoboli-indici* in Australia’, *Australasian Plant Disease Notes*, vol. 12(1), article 52.

Conference and workshop proceedings

Allen, LR 2017, ‘Managing pests with exclusion fences: progress and potential biodiversity benefits’, *17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra.

Austin, P, Stampa, D & Vitelli, JS 2017, ‘Eradication of red witchweed—one step at a time!’, *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane, pp. 21–26.

Bickel, TO, Perrett, C, Vitelli, J, Xu, J & Adkins, S 2018, 'Control of *Cabomba caroliniana* with flumioxazin: control efficacy and the effect of environmental factors', *15th international symposium of aquatic plants*, Queenstown, New Zealand.

Brooks, S 2017, 'What can I do with weed control data?', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane, pp. 119–126.

Callander, JT, Shi, B, Raghu, S & Dhileepan, K 2017, 'Biological control of parthenium: progress on the redistribution of established agents to southern Queensland', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane, pp. 72–76.

Cremasco, P & Bacchiella, D 2017, 'A strategy for effectively managing feral pig impacts in agricultural enterprises in northern Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 141.

Fancourt, B, Speed, J & Gentle, M 2017, 'Do dingoes suppress feral cats? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 119.

Forsyth, D, Pople, T, Page, B, Moriarty, A, Ramsey, D, Parkes, J, Wiebkin, A & Lane, C (eds) 2017, *2016 national wild deer management workshop proceedings, Adelaide, 17–18 November 2016*, Invasive Animals Cooperative Research Centre, Canberra, Australia.

March, N, Vogler, W & Dhileepan, K 2017, 'Advancing prickly acacia management through the war on western weeds initiative', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Osunkoya, OO, Moore, K, Shi, B & Dhileepan, K 2018, 'Parthenium weed has limited impact on soil chemistry/biochemical activities but drives above and below ground biodiversity', *Proceedings of the 21st Australasian weeds conference*, The Weed Society of New South Wales, Sydney.

Pukallus, K, Day, M, Riding, N & Clark, J 2017, 'Update on biological control agent, *Aceria lantanae* (lantana bud mite) on *Lantana camara* in northern Queensland', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane, pp. 10–15.

Setter, MJ, Setter, SD & Styman, DT 2017, 'Survival and buoyancy of *Hygrophila costata* stem fragments in salt, brackish and fresh water', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Setter, SD, Graham, Michael F, Setter, MJ & Waterhouse, BM 2017, '*Limnobium laevigatum* (Amazonian frogbit) ecology and control in the Wet Tropics', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Snow, L & Day, M 2017, 'Biological control: not as simple as it seems', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane pp. 77–81.

Taylor, DBJ, Snow, EL, Moore, K & Dhileepan, K 2017, 'At last, biological control of bellyache bush', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane, pp. 4–9.

Vogler, W 2017, 'To burn or not to burn: using fire to manage a complex grass ecosystem', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Vogler, W, Carlos, E & Hosking, K 2017, 'Extending flupropanate use—spot application on perennial mission and gamba grass', *Proceedings of the 14th Queensland weed symposium*, The Weed Society of Queensland, Brisbane.

Wilson, C, Fancourt, B, Speed, J & Gentle, M 2017, 'Home range and habitat utilisation of feral cats (*Felis catus*) in central Queensland', *Proceedings of the 17th Australasian vertebrate pest conference*, Invasive Animals Cooperative Research Centre, Canberra, p. 99.

Reports, newsletters, fact sheets and theses

Bickel, TO, Vitelli, J & Sathyamurthy, R 2018, *Integrated management of caboma*, milestone report (submitted to Department of Agriculture and Water Resources), Department of Agriculture and Fisheries and CSIRO, Brisbane, 6 pp.

Biosecurity Queensland 2018, *Coral cactus*, fact sheet, Queensland Government.

Biosecurity Queensland 2018, *Devil's rope pear*, fact sheet, Queensland Government.

Biosecurity Queensland 2018, *Hudson pear*, fact sheet, Queensland Government.

Biosecurity Queensland 2018, *Snake cactus*, fact sheet, Queensland Government.

Campbell, R 2017, *Influence of soil type on flupropanate availability: a case study on managing weedy* Sporobolus *grasses*, Hons thesis, The University of Queensland, Brisbane.

Dhileepan, K & Callander, J 2018, *Parthenium biological control*, final report (B.WBC 0700) submitted to Meat & Livestock Australia, p. 54, 30 April.

Gentle, M, Allen, B & Speed, J 2017, *Peri-urban wild dogs in north-eastern Australia: ecology, impacts and management*, PestSmart toolkit publication, Centre for Invasive Species Solutions.

Harriott, L 2018, *Prevalence, risk factors, and geographical distribution of zoonotic pathogens carried by peri-urban wild dogs*, PhD thesis, The University of Queensland.

Hughes, L 2017, *How effective is rabbit haemorrhagic disease virus (K5 strain) in reducing the abundance of the introduced European rabbit (*Oryctolagus cuniculus*)*, Hons thesis, The University of Queensland.

Junfeng, X 2017, *The efficacy of flumioxazin for controlling two introduced and two native aquatic weeds in Queensland*, Masters thesis, School of Agriculture and Food Sciences, The University of Queensland.

Lock, C 2018, 'Investigation of endemic fungal pathogens for the biological control of giant rat's tail grass (*Sporobolus* spp.) in Australia', Hons thesis proposal as part of the requirements for ENVM4200, School of Earth and Environmental Sciences, The University of Queensland, St Lucia, 31 pp.

McConnachie, A, Day, M & Jones, P 2018, *Cylindropuntia biological control RnD4Profit-14-01-040*, final report (submitted to Department of Agriculture and Water Resources), Meat & Livestock Australia, Sydney, 22 pp.

Vitelli, JS, Williams, AM, Riding, N, Chamberlain, A, Austin, P & Stampa, D 2017, 'RWW research update', *2016–17 annual report to the RWW Consultative Committee*, 22 August.

Wang, R 2018, *Determining density thresholds for managing rabbit damage to broccoli and corn*, Masters thesis, The University of Queensland.

Media

Dhileepan, K 2018, *Cat's claw creeper*, radio interview, ABC Southern Queensland, 17 March.

Elsworth, P 2018, *Rabbits in Rockhampton*, ABC Radio Rockhampton, 29 April.

Pukallus, K 2017, *Have you seen galls on lantana bushes?*, ‹https://www.facebook.com/biosecurityqld›.

Vitelli, JS 2018, *Endemic pathogens of giant rat's tail grass*, 'Queensland country hour', ABC, 20 March, interview by Kallee Buchanan.

Vitelli, JS 2018, *Natural assassin hunt uncovers new diseases that can be weaponised to fight invasive grasses*, 'Queensland country hour', ABC, 20 March, interview by Kallee Buchanan, ‹http://www.abc.net.au/news/rural/2018-03-20/new-pathogens-found-in-fight-against-weed-grass/9566052›.

Vogler, W 2018, *Giant rat's tail grass management*, 'Rural report' and 'Queensland country hour', ABC Rural Radio, 27–28 February.

Conference presentations

Bickel, TO 2017, 'Impacts of invasive aquatic plants on freshwater ecosystems', *ANGFA (Australia New Guinea Fishes Association) convention 2017*, Currumbin, 28–29 October.

Bickel, TO, Perrett, C, Vitelli, J, Xu, J & Adkins, S 2018, 'Control of *Cabomba caroliniana* with flumioxazin: control efficacy and the effect of environmental factors', *15th international symposium of aquatic plants*, Queenstown, New Zealand, 18–23 February.

Dhileepan, K, Shi, B, Callander, J, Teshome, M, Neser, S, Diagne, N & King, A 2017, 'Biological control of prickly acacia in Australia: prospective agents from Ethiopia and Senegal', *26th Asian Pacific Weed Science Society conference*, Kyoto, Japan, 19–22 September.

Fancourt, BA 2017, 'Avoiding the subject: the implications of avoidance behaviour for detecting predators', *12th international mammalogical congress*, Perth, 9–14 July.

Fancourt, BA, Cremasco, P, Wilson, C & Gentle, M 2017, 'Do dingoes suppress feral cats? Spatial and temporal activity of sympatric feral cats and dingoes in central Queensland', *30th Australasian Wildlife Management Society conference*, Katoomba, 5–7 December.

Shi, B & Dhileepan, K 2017. 'Biological control of parthenium weed (*Parthenium hysterophorus*) in China: opportunities from Australia', *26th Asian Pacific Weed Science Society conference*, Kyoto, Japan, 19–22 September.

Shi, B, Tang, S & Dhileepan, K 2018, 'Biological control of parthenium weed (*Parthenium hysterophorus*) in China: promising agents from Australia', *1st international congress of biological control*, Beijing, China, 14–16 May.

Forums and workshops

Allen, Lee 2017, *South East Queensland pest advisory forum*, Greenbank, 6 September.

Allen, Lee 2017, *Trapper training workshop*, Brian Pastures Research Station, Gayndah, 17–19 February.

Allen, Lee 2018, *Hinchinbrook Regional Council local government forum*, Ingham, 22–23 February.

Allen, Lee 2018, *Southern Gulf pastures, climate and pest forum*, Julia Creek, 27 April.

Bickel, TO & Sathyamurthy, R 2018, 'Cabomba: beauty and a beast, integrated control of *Cabomba caroliniana*', *ANGFA Qld meeting*, Clayton, January.

Day, MD 2017, *Biological control workshop*, Department of Agriculture and Water Resources, Canberra, 16 October.

Day, MD 2017, *44th annual workshop on biological control of weeds, research and implementation*, Rhodes University, Grahamstown, 30–31 October.

Day, MD 2017, *Workshop on mainstreaming invasive alien species management into university curriculum in Indonesia*, BIOTROP, Bogor, 29–31 August.

Day, MD 2018, *Workshop on economic and ecological impacts of invasive alien species*, Indian Statistical Institute, Kolkata, 21–22 February.

Dhileepan, K 2018, 'Biological control of Navua sedge: feasibility studies', *Project review meeting*, Malanda, 28 February.

Dhileepan, K 2018, 'Biological control of prickly acacia: research updates', *Prickly Acacia Alliance meeting*, Ecosciences Precinct, 18 June.

Dhileepan, K 2018, 'Update on biological control of weedy vines: cat's claw creeper and Madeira vine', *Cat's claw creeper and Madeira vine biocontrol workshop*, Noosa Landcare Rural Futures Centre, Pomona, 27 March.

Fancourt, BA 2017, 'Queensland research update', *Fifth Feral Cat Taskforce meeting*, Canberra, 30 November – 1 December.

Fancourt, BA 2018, 'Improving feral cat management in eastern Australia', *Feral cat management workshop*, Currawinya National Park, 21–23 May.

Gentle, M 2017, 'Improving feral cat management', *Mary River Environs Wild Dog (Pest Animals) Group*, Nambour, 25 October.

Gentle, M 2017, 'Improving feral cat management', *Queensland Invasive Plants and Animals Committee meeting*, Brisbane, 8 November.

Hosking, K 2018, 'Prickly acacia ecology research and management', *Shire rural lands officer forum*, Richmond, 22 March.

Jones, P 2017, *Hudson Pear Taskforce workshop*, Castlereagh Macquarie County Council, Lightning Ridge, 16 November.

Jones, P 2018, 'Biological control of *Cylindropuntia* cactus', *Gulf Catchment Pest Taskforce meeting*, Mount Isa, 17 April.

Jones, P 2018, 'Biological control of *Opuntia robusta*', *North Flinders* Opuntia *meeting*, Blinman, South Australia, 23 February.

Osunkoya, OO 2018, 'Queensland weed risk assessment—the journey so far', *Workshop on feasibility of management of Queensland invasive species*, Ecosciences Precinct, Dutton Park, 22 February.

Osunkoya, OO 2018, 'Queensland weed risk assessment and management', *IPA research review*, Ecosciences Precinct, Dutton Park, 14 May.

Pukallus, K 2017, *All things insect*, Fun Palace, Charters Towers Library, Charters Towers, 7 October.

Pukallus, K 2017, *Biological control overview*, Certificate II in Conservation and Land Management Program students from Jenagar, Tropical Weeds Research Centre, Charters Towers, 18 October.

Pukallus, K 2017, *Biological control overview*, The University of Queensland St Lucia Northern Tour students and glasshouse walk-through, Tropical Weeds Research Centre, Charters Towers, 12 July.

Vitelli, JS 2017, 'Herbicides—the ying and yang of weed control', *Joint Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day*, Tropical Weeds Research Centre, Charters Towers, 9 June.

Vitelli, JS 2018, 'GRT research update and its management', *Gladstone Regional Council community forum on giant rat's tail grass*, Miriam Vale Community Hall, Miriam Vale, 17 May.

Vitelli, JS 2018, 'Herbicide treatments and current GRT research', *Gympie Regional Council weedy* Sporobolus *forum day*, Prospectors Hall, Gympie Civic Centre, Gympie, 27 February.

Vogler, W 2017, 'Prickly acacia ecology for management', *Desert Channels Queensland/DAF BMP workshop*, Stamford, 8–9 November.

Vogler, W 2018, 'GRT fundamentals', *Giant rat's tail grass forum*, Gladstone Regional Council, 28 February.

Vogler, W 2018, 'GRT fundamentals', *Giant rat's tail grass forum*, Gympie Regional Council, 27 February.

Vogler, W 2018, 'GRT fundamentals', *Local government giant rat's tail grass forum*, Rockhampton, 1 March.

Vogler, W 2018, 'Prickly acacia ecology research and management', *Southern Gulf NRM forum*, Julia Creek, 27 April.

Lectures and seminars

Bickel, TO 2018, *Weed science PLNT3012/6894: aquatic plant ecology and management*, The University of Queensland, Gatton, 12 March.

Brooks, SJ 2017, *Research on eradication target species*, The University of Queensland students, Charters Towers, 12 July.

Brooks, SJ 2017, *Science week; Science, technology and the weed wide web*, Blackheath and Thornburgh College, Charters Towers, 17 September.

Brooks, SJ 2018, *Introduction to weeds*, Blackheath and Thornburgh College Year 7 students, Charters Towers, 21 March.

Campbell, SD 2017, *Introduction to the Tropical Weeds Research Centre*, The University of Queensland students, Charters Towers, 13 July.

Day, MD 2018, *Biological control of weeds*, The University of Queensland, Gatton, 8 May.

Dhileepan, K 2017, *Management of alien invasive species in forests and protected areas in India*, Institute of Forest Genetics & Tree Breeding, Coimbatore, India, 12 September.

Dhileepan, K 2018, Weed science *PLNT3012: biological control weeds-2*, The University of Queensland, Gatton, 8 May 2018.

Elsworth, P 2018, *Vertebrate biocontrol*, Veterinary School, The University of Queensland, Gatton, 30 April.

Gentle, M 2018, *Vertebrate pests—overview and control strategies*, Veterinary School, The University of Queensland, Gatton, 26 February.

Lock, C 2018, *Biological control of giant rat's tail grass using endemic fungal pathogens*, School of Earth & Environmental Science, The University of Queensland, St Lucia, 18 May.

Vogler, W 2017, *War on western weeds initiative*, The University of Queensland Tropical Weeds Research Centre visit, Charters Towers, 12 July.

Vogler, W 2018, *Prickly acacia and giant rat's tail grass: managing risk, reducing spread*, Regional Pest Management Group meeting, Charters Towers, 13 June.

Vogler, W 2018, *Prickly acacia and giant rat's tail grass spread: managing cattle, reducing the risk*, Beef Australia 2018, Rockhampton, 10 May.

Field days

Brooks, SJ 2017, 'High-risk invasive weeds and prevention' (on behalf of Steve Csurhes), *Dry Tropics pest advisory forum and Tropical Weeds Research Centre open day*, Charters Towers, 9 June.

Callander, J 2018, 'Parthenium weed biocontrol', *Healthy Land and Water*, Junction View, 20 April.

Callander, J 2018, 'Parthenium weed biocontrol', *Healthy Land and Water*, Kilcoy, 18 April.

Elsworth, P 2017, 'Rabbit control: warren ripping demonstration', *Rabbit management field day*, The Summit, 19 September.

Elsworth, P 2017, 'Weeds and rabbits', *Rabbit management field day*, Warwick, 13 December.

Elsworth, P 2018, 'Rabbit control: warren ripping demonstration', *Rabbit management field day*, Highfields, 17 April.

Elsworth, P 2018, 'Weeds and rabbits', *Rabbit management field day*, Maryvale, 22 May.

Hosking, K, 2017, 'Prickly acacia ecology', *Southern Gulf NRM field day*, Richmond, 27 September.

Jones, P 2018, 'Biological control of rope pear', *Condamine Alliance field day*, Warwick, 28 March.

Pople, A & Brennan, M 2018, 'Ecology and management of chital deer', Gainsford Station, June 2018.

Riding, N 2018, 'Biological control of rope pear', *Condamine Alliance field day*, Warwick, 28 March.

Vitelli, JS 2018, 'Update on the latest in biocontrol research for GRT', *Bundaberg Regional Council GRT field day and farm walk*, Tirroan, 16 March.

Vogler, W 2017, 'Grader grass ecology and management', *NQ Dry Tropics grader grass forum*, Giru, 22 October.

Vogler, W 2018, 'Prickly acacia ecology and management', *Desert Channels Queensland prickly acacia field day*, Audreystone Station, Barcaldine, 21 March.

STEM Professionals in Schools

Pukallus, K 2017, *Insects and ecosystems*, Reef Guardian Day, Blackheath and Thornburgh College, Charters Towers, 26 July.

Pukallus, K 2017, National Science Week, lunchtime activities, 'Future earth' theme, Millchester State School, 7–9 August.

Technical highlights
Invasive plant and animal research 2017–18

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